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*Dead-ending open wires with
a rolled-sleeve joint.*



Regulation for the J-2 Carrier Telephone System

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the attenuation-frequency curve. To compensate for this variation in slope and attenuation, it is necessary to measure the loss at two frequencies—preferably near the edges of the frequency band involved—and then to provide a complementary repeater-gain characteristic.

IN THE J-1 carrier system, a single pilot frequency located near the middle of each of the 12-channel bands is employed for regulating the transmission gain. A single pilot channel is adequate under ordinary weather conditions because in the entire range of wet and dry attenuation over the normal temperature range, the slope of the attenuation curve bears a reasonably definite relationship to the loss at the mid-band frequency. A J-1 system 1000 miles long can be controlled so that all channels are within about 2 db for dry or wet weather from zero to one hundred degrees Fahrenheit.

Where severe ice, sleet, or snow is encountered, however, a single pilot for each band is not adequate. Conditions giving the same loss at mid-frequency may give losses over a single repeater section differing by more than 5 db at the edges of the band. Moreover, marked changes occur in both attenuation and slope of

Since the J-2 system was developed primarily to obtain better results on lines where these adverse conditions are encountered, two pilot frequencies are employed, one at each end of the band. The pilot at one edge is used to control a gain that is the same for all frequencies, and the pilot at the other edge, a gain that varies with frequency from practically zero at one edge of the band to a maximum value at the other. The action of the regulator for the east-to-west band, extending from 92 to 143 kc, is indicated in Figure 1. The flat gain is controlled by the pilot at 92 kc, and the slope gain, by a pilot at 143 kc. When the level of the 92-kc pilot drops, the regulator acts to raise the gain at all frequencies by the same amount up to a maximum of 45 db. When the level of the pilot at 143 kc drops, however, the regulator produces a gain that increases linearly with frequency from almost zero at 92 kc to any value between zero and a maximum of 35 db at 143 kc. It thus tilts the gain-frequency curve upward

at the right-hand end. The dotted curves show possible characteristics when the flat regulator has produced no gain, and the solid curves, when it has produced its full gain of 45 db. Intermediate curves might lie anywhere between these extremes.

For the west-to-east band, from 36 to 84 kc, a similar scheme is employed, but here the flat gain is controlled by the upper pilot frequency and the slope gain by the lower. This results in a set of curves as indicated in Figure 3. The complementary action of the slope and flat-gain regulators is illustrated by the following example. Assume that this west-east repeater is operating with a gain corresponding to the dotted curve marked 60 and that an increase in attenuation occurs—over a period of time—that requires an additional gain of 22 db at 84 kc but only 11 db at 36 kc. The

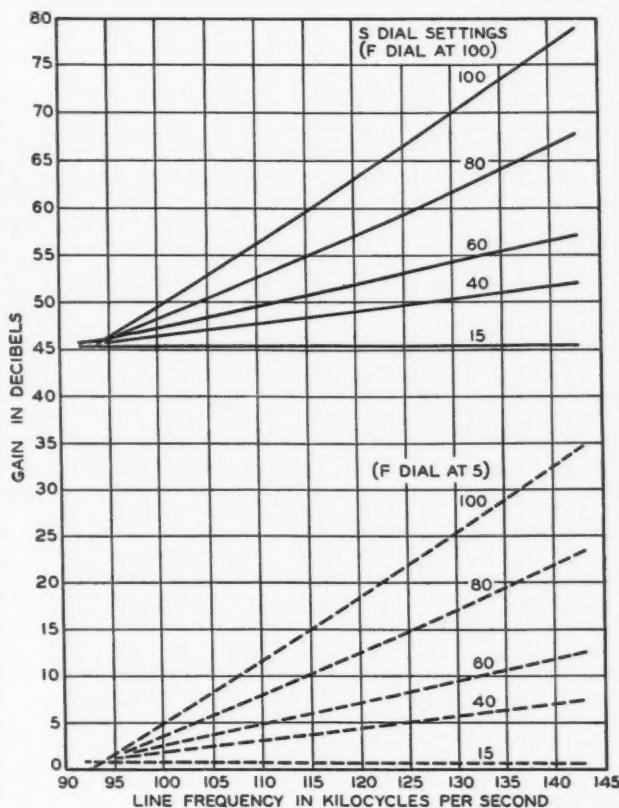


Fig. 1—Regulation available for east-to-west transmission: minimum and maximum flat gain and several values of slope gain

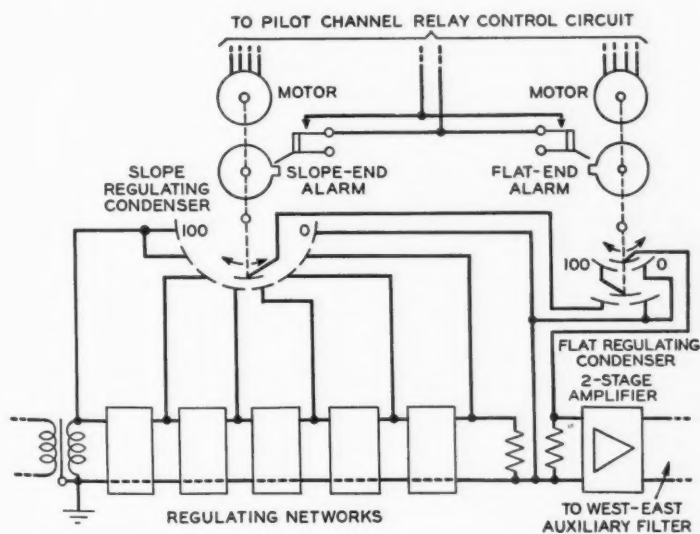


Fig. 2—Simplified schematic of circuit for west-to-east regulation in which both flat and slope regulators are used

flat regulator will act to insert the 22-db gain at all frequencies, but to keep the slope characteristics right, the slope regulator must remove about 11 db at 36 kc.

It will be noted that the flat-gain pilots are placed at the upper edge of the 36-84-kc band and at the lower edge of the 92-143-kc band, while the slope-regulating pilots are at the outer edges of these bands. This arrangement was selected be-

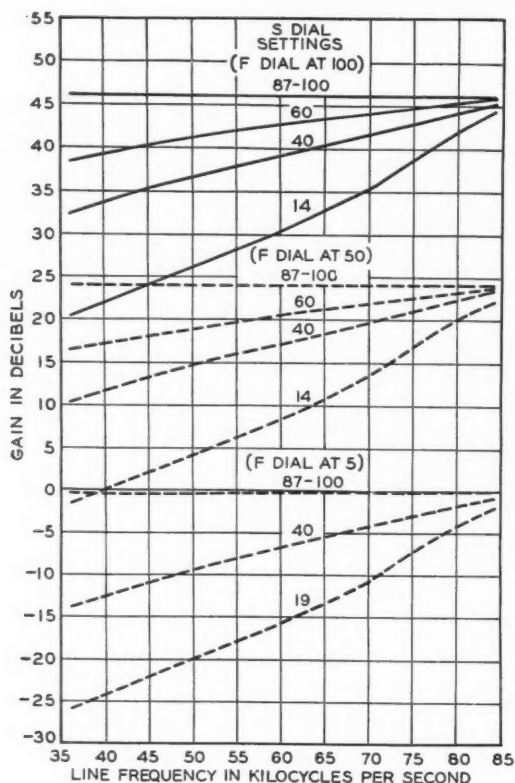


Fig. 3—Regulation available for west-to-east transmission: minimum, intermediate, and maximum values of flat gain

cause it imposes much less severe requirements on the directional filters than would be the case if either of the

slope-regulating pilots of the system were placed at the edge of the band that is adjacent to the crossover region of these filters.

In the regulator for the west-to-east, or low-frequency band, the flat and slope regulators operate condensers ahead of a two-stage feedback amplifier that in itself has a gain that is flat with frequency. The arrangement is shown in Figure 2. An increase in loss causes the flat regulator to rotate a double-stator condenser to increase the gain of the amplifier by increasing the potential on the grid of the first tube. The slope regulator moves a condenser with eight sets of stator plates that gradually introduce additional sections of series networks, each of which has a negligible loss at 84 kc and a linearly increasing loss that reaches its maximum value at the lower edge of the band, 36 kc.

The arrangement for the east-to-west, high-frequency band is shown in Figure 4. Here two amplifiers are employed: one for flat-gain and one for slope-gain control. The flat-gain amplification is controlled in much the same manner as for the low-frequency band. The networks for

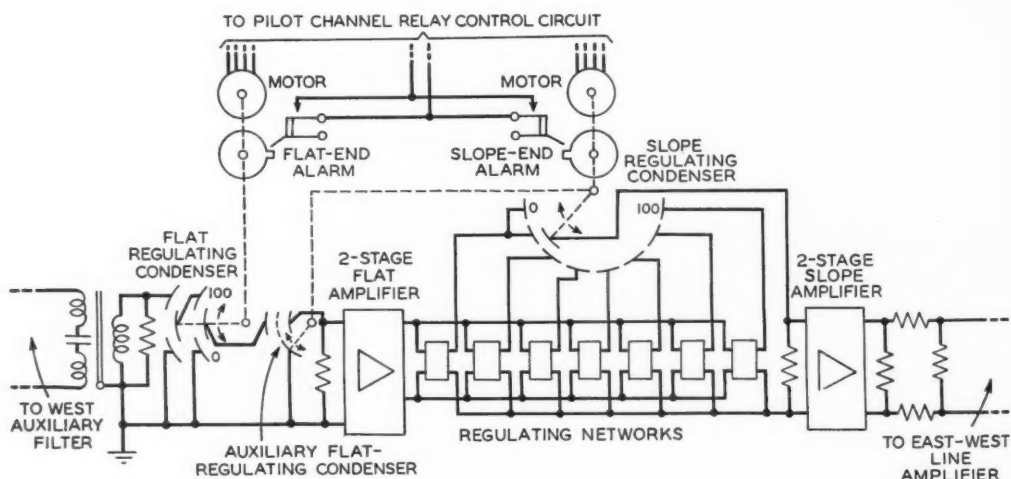


Fig. 4—Simplified schematic of circuit for east-to-west regulation

slope regulation differ in arrangement from those used with the west-to-east band in being cut into the circuit in parallel instead of in series. The slope of these various networks in combination with about 10 db of slope introduced by the line amplifier conforms to different slope characteristics of open-wire lines ranging from the coldest and shortest dry line to the steepest and highest-attenuation iced-line characteristic expected before noise renders further gain useless. In the flat-gain regulating circuit there is an auxiliary condenser driven by the slope control. It comes into play only for low-slope conditions, that is, when little or no gain is required from the slope control.

An example of the action of the regulator under adverse weather conditions requiring the use of the auxil-

iary condenser is shown in Figure 5. This consists of nine graphs side by side plotting signal level against frequency at the beginnings and ends of a series of repeater sections. In normal operation the output of each repeater would be flat with frequency, and at a level not greater than +17 db. Such an input to section 1 is shown, and the loss over section 1 results in a level at the end of the section that decreases with increasing frequency. The total loss is moderate, and the combination of flat and slope regulators restores the signal to a flat +17 db at the input to section 2.

Over sections 2, 3, and 4 it is assumed that the ice or snow that coats the wires causes a very large attenuation with only moderate slope. The loss at 92 kc is so great that the 45-db flat gain of the next three repeaters

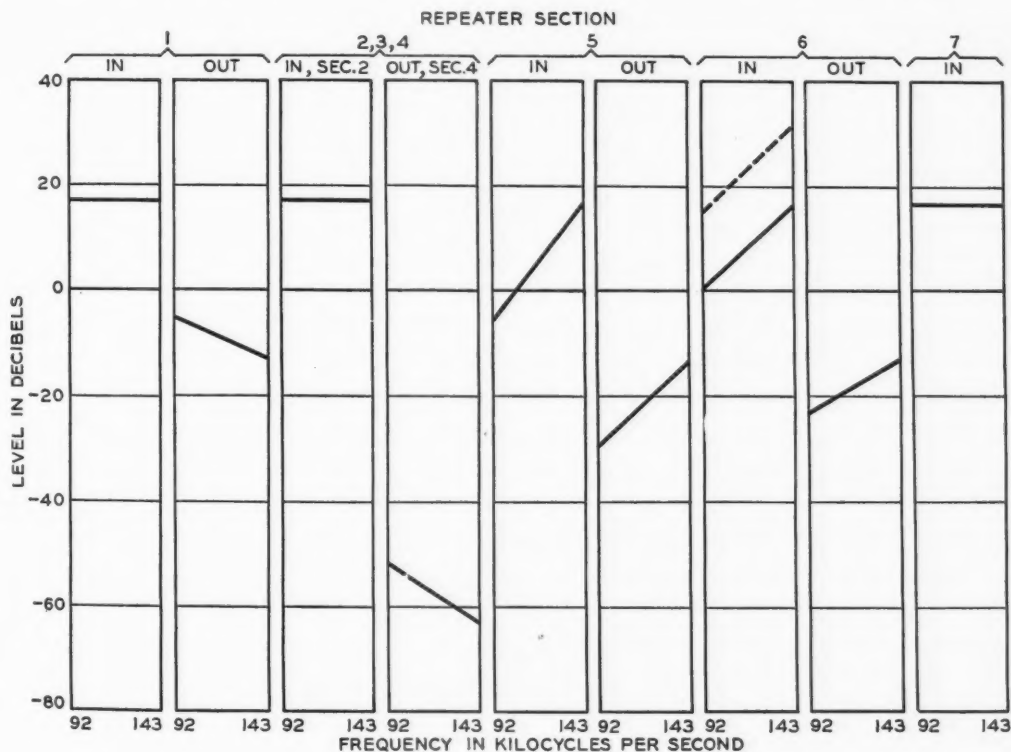


Fig. 5—Level-frequency graphs for the input and output levels over a number of sections in series under adverse weather conditions requiring the use of auxiliary condenser

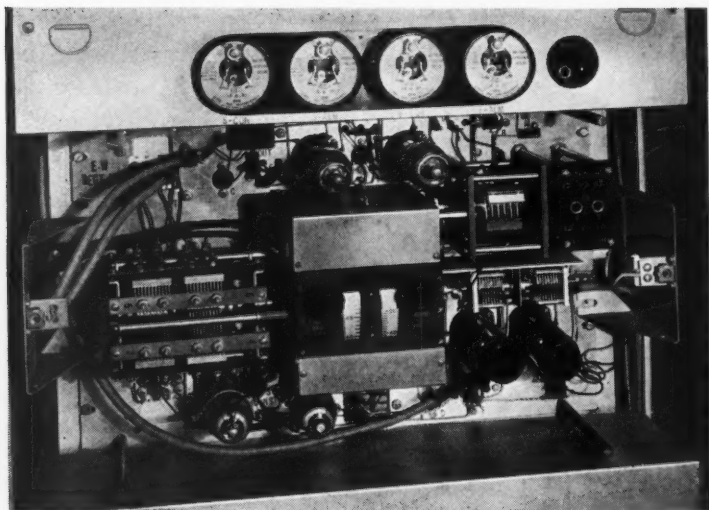


Fig. 6—The east-to-west band regulator with cover removed

can raise the level at the low frequencies to only -7 db at the input to section 5. The total of 80 db available at the high frequencies of each repeater, however—made up of 45-db flat regulation and 35-db slope regulation—is ample to bring the level of the high frequencies up to the desired $+17$ db. As a result the signal leaves the repeater at the beginning of section 5 with a level that increases with increasing frequency—a reversed slope, as compared with the preceding sections. This next section, it is assumed, is a comparatively short one, operating under ordinary dry or wet weather conditions. The reversed slope is therefore decreased, but the total attenuation is small. The flat regulator at the end of this section inserts its full 45 db in an effort to bring the level at 92 kc up to $+17$, but in doing so, it raises the level at 143 kc to

$+32$, as indicated by the dotted line, even without any slope gain added. This would put too high a level on the line, and it is for this reason that the auxiliary flat condenser is added. Coming into play when the slope regulator is at its low end, it introduces a flat loss that results in the solid line. The next sections take out enough of the reverse slope to enable the following repeater to re-

store the signal to a flat $+17$ db.

Both flat and slope regulators for both frequency bands are operated by circuits essentially the same. The pilot is picked off through pilot-channel filters at the output of the line amplifier and passed through an amplifier and rectifier to the windings of two relays—one to give the control and one for alarms under exceptional conditions. One of the two pilots of each band is carried to two relays associated with the flat control, and

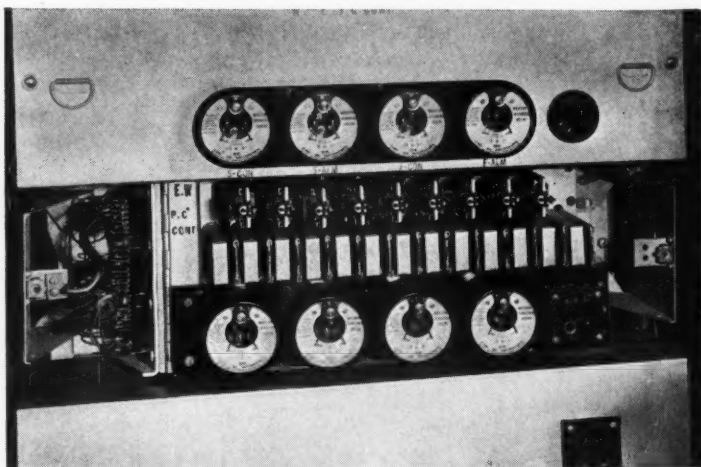


Fig. 7—Control circuit panel for both bands

the other, to two similar relays associated with the slope control.

The relays used for regulating purposes are on the panel, the front and rear views of which are shown in Figures 7 and 8. Since the relay circuit closely parallels the one used in the 2B pilot channel regulator for type-C carrier systems, a detailed description of the circuit and its functioning is not given at this time. Complete description of the 2B circuit will be given in an article to appear soon in the RECORD.

A test installation of these regulators in the Laboratories is shown in the photograph at the head of this article, and a close-up view of the high-group regulator with cover removed is shown in Figure 6. The flat-control condensers are at the right, with the auxiliary flat-control condenser above them, while the slope-control condensers are at the left. The dials near the center indicate the positions of the two sets of condensers. Knobs are provided for manual drive of the regulating condensers. The driving motors are mounted on the rear of the panel, in the manner shown in Figure 8.

Although this pilot-channel control circuit was designed to compensate for changes in line attenuation, it has the additional advantage of keeping continuous watch on the operation of the system as a whole. If the entire transmission circuit, clear back to the

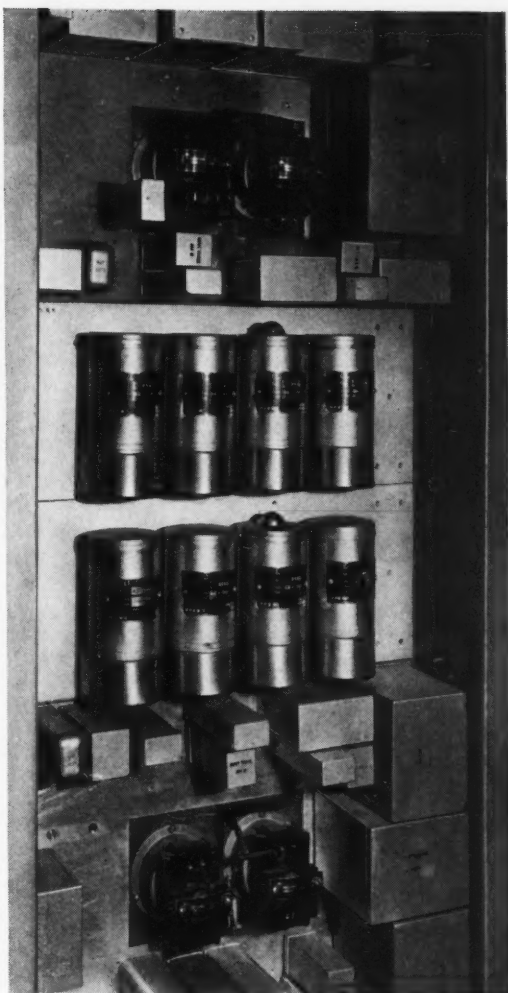


Fig. 8—Rear view of bay shown in the photograph at the head of this article

originating terminal, is not intact, an alarm will at once be given. The simultaneous alarms caused by unstable or failing pilots will be the first indication of an overall circuit trouble.



Dielectric Properties of Pigmented Rubber

By D. B. HERRMANN
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is usually the largest constituent except rubber hydrocarbon. For this reason and also because it is often a semiconductor its effects on the insulating characteristics of the compound are generally more marked than those of the other materials. A conducting pigment dispersed in rubber may form conducting paths and change the dielectric

GOOD insulation for wire is characterized by a low dielectric constant, low power factor, and a high resistance to the passage of direct currents. Its life should be measurable in years, for the longer an insulated wire or cable can be kept in service without repair or replacement the better. Pure rubber fulfills the dielectric requirements but to give it all of the requisite physical properties it must be compounded with other materials in various combinations and vulcanized by combining it with sulfur. These other materials are called accelerators, antioxidants or antiagers, plasticizers or softeners, and pigments. All affect the dielectric properties of rubber in varying degrees.

The pigment* in rubber insulation

*The word "pigment" is used here in a general sense, including not only true pigments but also inert fillers and reinforcing agents. The demarcation of these groups is indefinite.

properties more than an insulating pigment similarly dispersed. In most cases the pigments increase the dielectric constant, power factor, and conductivity, and decrease the direct-current resistivity of rubber compounds. Their use, however, reduces cost, increases toughness and tensile strength, and provides different colors.

Reinforcing pigments, which are used to strengthen rubber, have higher dielectric constants than rubber. Their addition therefore raises the dielectric constant of rubber compounds. There is no exact mathematical relation, however, for calculating accurately the dielectric constant of a rubber compound from the dielectric constants of its components. Many factors other than the dielectric properties of pigment probably affect the dielectric properties of rubber compounds. Among these are

size, shape, and uniformity of the particles, degree of dispersion in the rubber, wettability by the rubber, and impurities in the pigments including those adsorbed on particle surfaces. Various pigments contribute different characteristics and different grades also have different effects.

Vulcanized pigmented rubber in sheets or slabs about 6 inches square provide a convenient form for dielectric measurement. To them are attached tin-foil electrodes with a very thin layer of petrolatum as an adhesive to insure good contact. The upper electrode is guarded by a tin-foil ring cut to fit closely around it so that capacitance edge effects are reduced to a negligible minimum. The electrode dimensions are selected to give a reasonable capacitance value and to fit a brass disc and shield which connect the upper electrode and guard ring with the shielded capacitance-conductance bridge used for alternating-current measurements at low frequencies. The sheet and top electrode are set on a smooth steel plate which is in contact with the lower electrode and is also connected to the bridge. D-c resistivity measurements are made with a galvanometer

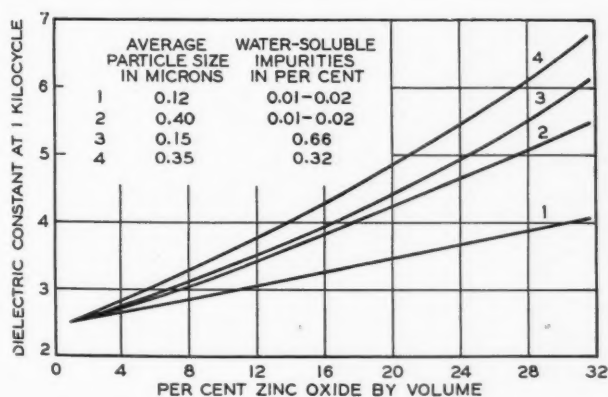


Fig. 1—The amount and kind of zinc oxide in rubber insulation are important in determining the dielectric constant of the insulation

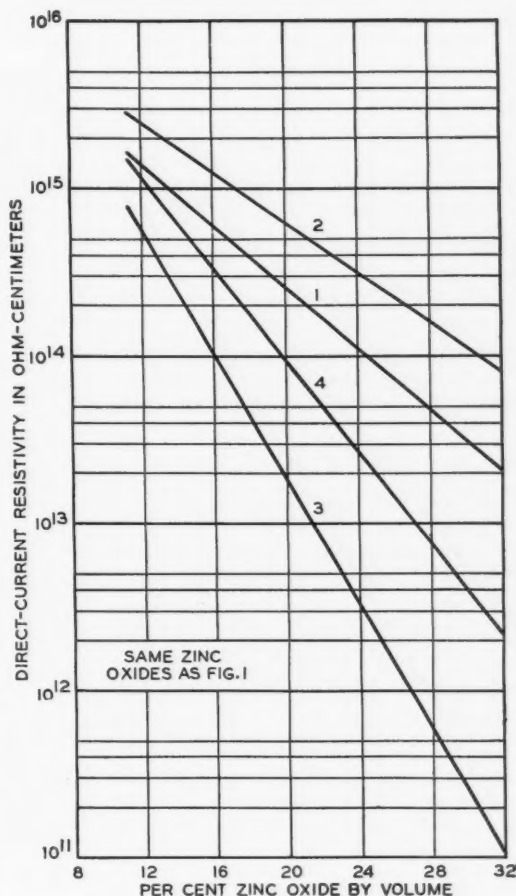


Fig. 2—The effect of various zinc oxides is shown by direct-current resistivity measurements of zinc oxide rubber compounds which have been soaked in water

by a direct deflection method.

Zinc oxide, which is both a reinforcing agent and a true pigment, finds considerable use in rubber insulation although it is a semi-conductor. Figure 1 shows that zinc oxides with the least water-soluble impurities give the lowest dielectric constants and that the grades with fine particles have less effect than those with coarse. The conductivity and power factor of rubber are influenced in a similar manner. In Figure 2

is shown the difference between the direct-current resistivities of compounds containing the same four types of zinc oxide as those of Figure 1. The measurements were made on test sheets which had been immersed in distilled water at 25 degrees Centi-

highest percentage of water-soluble impurities. The advantages gained by purifying rubber to remove water-absorbing materials are partly lost if pigments are used which contain soluble impurities.

That the adverse effects of water-soluble matter are increased by the presence of water for other pigments besides zinc oxide is indicated in Figure 3. The increase in dielectric constant with the amount of pigment in a rubber compound containing incompletely processed lithopone is greatly magnified by exposure to water as compared with the increase for the same compound when made with processed lithopone, because the processing removes soluble materials. The sheets were kept in distilled water at 25 degrees Centigrade for 28 days before the test, as was done with the zinc oxide rubber compounds. The difference between the effects of the two types of lithopone when the test sheets are dry is relatively small at even the highest volume percentage shown. Lithopone is a mixture of about thirty per cent zinc sulfide and seventy per cent barium sulfate and is an inert filler compared with zinc oxide. It is made by simultaneous precipitation of barium sulfate and zinc sulfide from solutions of barium sulfide and zinc sulfate. If water-soluble salts are not completely removed the pigment has a deleterious effect on the insulating properties and characteristics of rubber compounds.

Whiting, or calcium carbonate, is a pigment frequently used in rubber compounding. It is coarser than zinc oxide and not as readily wetted by rubber. Unlike zinc oxide, it is an insulating pigment and therefore has less influence on the dielectric properties of rubber. In general, however, rubber compounds which contain

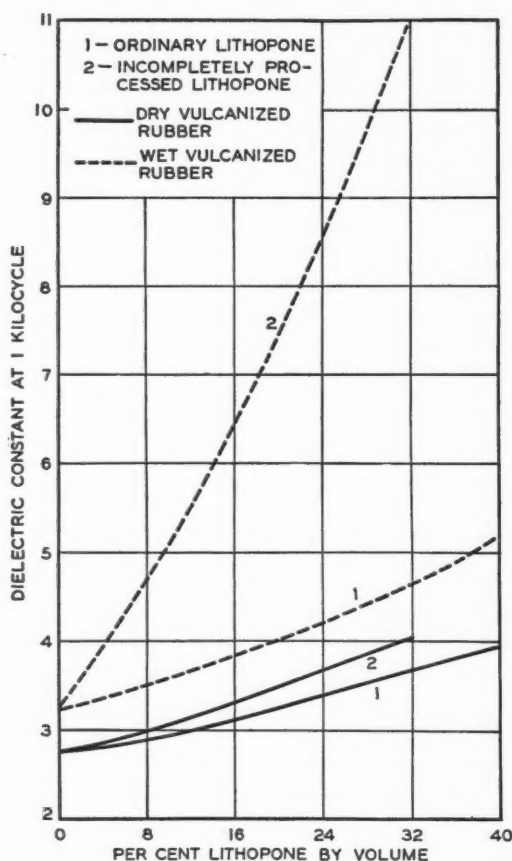


Fig. 3—A striking difference is found in the effect of two lithopone pigments on the dielectric constant of rubber insulation which has been exposed to water

grade for 28 days. Rubber compounds made with zinc oxides which contain very little water-soluble material have the highest resistivities and fine particles lower the resistivities somewhat. Dry sheets have much higher resistivities but the zinc oxide which causes the lowest resistivity in the dry as well as the wet compound has the

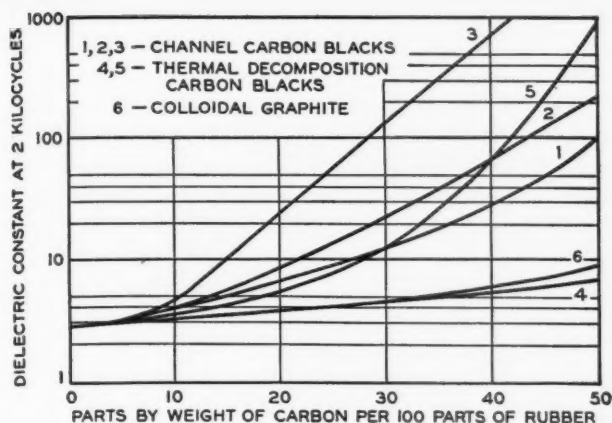


Fig. 4—The increase in the dielectric constant of vulcanized rubber varies considerably with the addition of different carbon pigments

whiting have dielectric properties close to those of insulation made with equivalent volumes of the better zinc oxides. Like other pigments, various whittings differ in the degree to which they affect dielectric properties of rubber compounds. For example, a ground limestone gave better insulating properties than a precipitated calcium carbonate when both pigments were well dispersed. The calcium carbonate had a smaller particle size and varied more in alkalinity. Alkalies are water soluble and are undesirable in insulation.

The effect of different types of carbon on the dielectric properties of rubber varies much more than does that of zinc oxide, as Figures 4, 5 and 6 indicate. The various carbon pigments include true pigments, reinforcing agents, and inert fillers. By their use rubber compounds may be prepared with widely different physical and dielectric properties. It is almost possible to

duplicate the entire range of properties attainable with other pigments by using carbon alone. Channel process carbon blacks, which are manufactured by incompletely burning natural gas against metal beams or channels, are by far the best reinforcing agents known, but unfortunately they affect the insulating properties of rubber more adversely than any other pigment. The coarser thermal-decomposition blacks, which are made by breaking down hydrocarbon gas into carbon and hydrogen, and colloidal graphite give relatively low reinforcement and act like inert fillers. Blacks made by

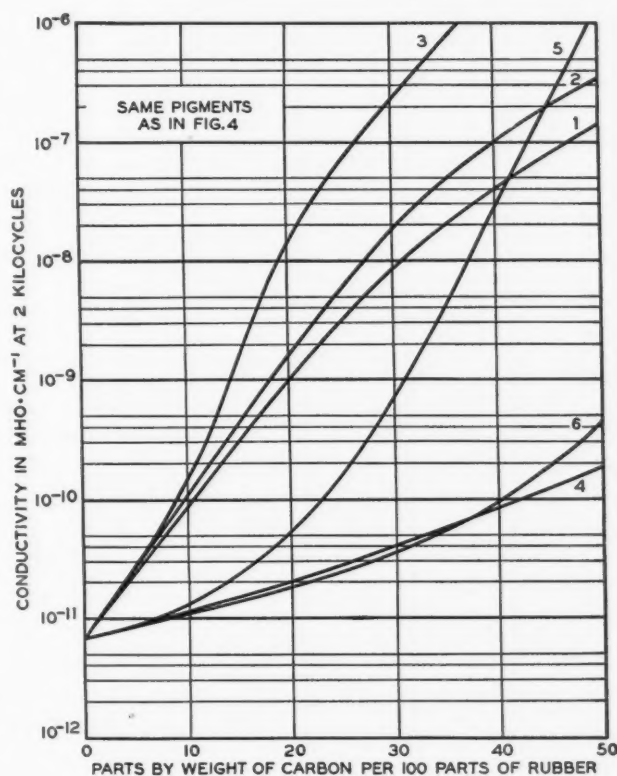


Fig. 5—The conductivity of vulcanized rubber can be increased over a million times by adding large amounts of certain carbon pigments

thermal decomposition are conducting and have particles of nearly the same size as zinc oxide. Channel black has an average particle size considerably smaller than that of soft (thermal decomposition) black or zinc oxide. The evidence implies that the dispersion of channel black in rubber is of a

These effects are striking for larger amounts of pigment. The addition of carbon up to ten parts in one hundred of rubber has relatively little adverse effect on dielectric constant and resistivity as compared with higher proportions. The conductivity and power factor of rubber are increased by the addition of very small amounts of carbon black and are more sensitive than the dielectric constant or direct-current resistivity to these additions. They are also more sensitive as measures of particle size and degree of dispersion. The addition of ten per cent of the finer blacks increases the conductivity by about tenfold; the addition of fifty per cent may increase it more than a million times. In fact, certain types of carbon black convert rubber from an insulator to a semiconductor.

Many other pigments are added to rubber to alter its physical properties, including magnesium carbonate and oxide, lead and titanium oxides, barium sulfate, talc, and clays. Nearly all are available in various grades and these studies show that the effect of each grade, as well as each pigment, on the dielectric properties of rubber insulation must be considered.

These investigations of the effect of pigments, fillers, and reinforcing agents on the dielectric properties of rubber compounds have found practical application in the development of better-insulated wire that is used throughout the telephone plant.

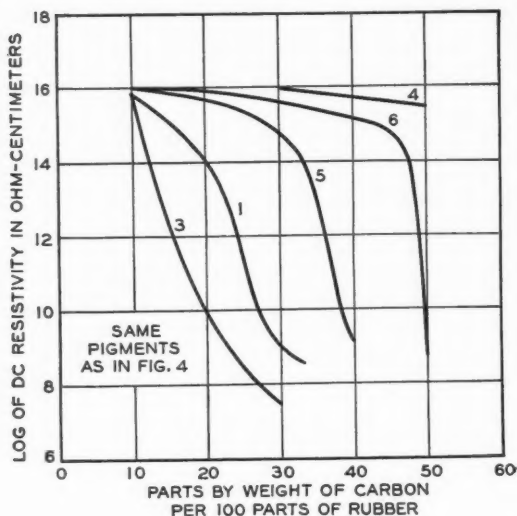


Fig. 6—There is a wide variation in the effect of carbon pigments on the direct-current resistivity of vulcanized rubber

different nature than that of other carbon pigments. The increase in dielectric constant caused by this black is augmented by increased working of the compound, which presumably corresponds with improved dispersion.

The finer the particle size of carbon the higher the dielectric constant and conductivity a given amount of it imparts and the lower the resistivity.

Protecting Switchboard Lamps With Varistors

By W. E. DARROW
Local Central Office Facilities

IN 1931 a new switchboard, known as the No. 12,* was developed to furnish common-battery service in small towns formerly served by magneto equipment. One of the new features of this board was a simplified line circuit having the line lamp connected directly in series with the line conductors, so that no line relay was needed. Subscriber loops connecting with these central office switchboards may vary from virtually zero to six or seven hundred ohms, and prior to the No. 12 board, there had been no switchboard lamp available that would give satisfactory illumination over such a range of resistance. At the time the development of the No. 12 board started, however, the Laboratories had just completed the development of a new high-resistance tungsten-filament switchboard lamp that would stand over-voltages of fifty per cent for a considerable period of time, and would give good illumination down to sixty per cent of its rated voltage. It seemed ideal as a series line lamp, and was adopted for the No. 12 board. By using cut-off jacks with this lamp, a line circuit was designed that required no relays at all.

*RECORD, Dec., 1932, p. 94.



It was realized that line lamps in this type of line circuit would be exposed to any electrical disturbances that might be impressed on the outside lines, and that these disturbances might be of such severity in a few cases as to require line relays to prevent lamps from burning out. However, the new line circuit effected substantial economies over the line-relay type, and it was decided to employ it in all cases and, where required, add line relays or make such other modifications as experience might indicate would be necessary. On a number of early jobs recurring lamp failures during thunderstorms were experienced on some of the lines. Usually, not more than twenty-five per cent of the lines were involved, and the troubles were eliminated by equipping them with relays. Investigation showed that these lamp failures were caused by surges of very short duration, and this indicated that a simpler and more economical method

of preventing lamp failures could be devised. Bridging the lamps with some varistant material that would provide a low resistance shunt around them for the duration of the surge seemed to be the best solution.

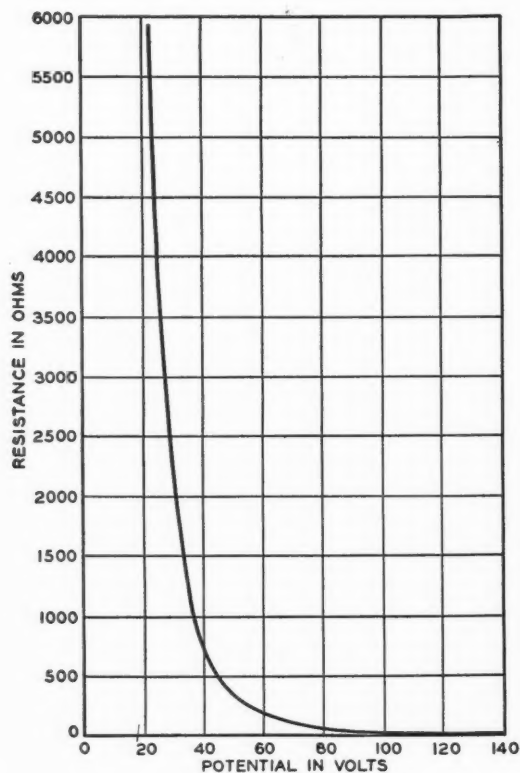


Fig. 1—Resistance-voltage characteristic of varistor used for protecting line lamps in the No. 12 type switchboard

Silicon carbide was proposed since its resistance decreases at a high rate and almost instantaneously as the voltage across it rises. If such an element shunted around the lamp could be given a high normal resistance so as to have no appreciable effect on the illumination, and if its resistance decreased sufficiently under high-voltage conditions, it would act as a very effective protection against burnouts by limiting the voltage across the lamp. In addition, of

course, the varistor should restore to its normal condition after each application of high voltage, and should not change appreciably with age.

Possible applications of silicon carbide varistors in the telephone plant had been under investigation, and a disk had been developed that had a tenfold decrease in resistance for each doubling of voltage, and that also met the resistance and voltage requirements. As shown in Figure 1, this varistor drops to a low resistance at the higher voltages, and should therefore adequately protect the lamps on all telephone loops of only moderate resistance.

The varistor element is a silicon carbide and clay disk. Each disk is placed between fairly heavy metallic plates, which provide the electrical connections to the disk and also dissipate any heat that might be developed in them. A substantial number of lamps are likely to need protection in an office, and because of the small space occupied by each element, twenty of them are mounted in a unit known as the 300A varistor, shown in Figure 2. The varistors are assembled in pairs—two disks and three metal plates. The center plate forms a common terminal for the two disks, and the two outside plates form the individual terminals. Ten such pairs form the 20-disk unit, and the common terminals of all ten pairs are strapped together. They are assembled on a metal rod with mica insulation between pairs and a ceramic bushing over the rod. End plates are provided for fastening the unit on a standard mounting plate. Four such assemblies can be mounted on a single mounting plate, and provide protection for eighty lines. The mounting plates can be located either in a switchboard section or on a relay

rack, if one is available. A mounting detail was developed to permit locating the 300A varistors between the verticals of the main frame. An installation of this type is shown in the photograph at the head of this article. Figure 3 shows the compactness of the 300A varistor as compared with twenty line relays.

The varistors were found to be very effective in protecting the line lamps in several trial installations, and they have been standardized for general use throughout the Bell System. When they are mounted in the switchboard section or on a relay rack, they are cabled to terminal punchings on the main frame—only one conductor being required for each varistor element. Thus, wherever the varistors are mounted, their protective elements are accessible at the main frame for cross-connection to the line-lamp circuits.

Only a very simple change was made in the wiring of the standard line circuit because of the addition of the varistors, and this was in the cable between the main frame and the switchboard. Originally, this cable had two conductors for each line, one serving as the tip and the other as the ring conductor—while with the varistors, three conductors are required per line, the additional one to extend the lamp lead to the main frame. The cable has therefore been changed for all new offices to one having three conductors per line. The

line circuit is of the lamp-in-the-multiple type, with a lamp socket associated with each multiple jack of the line. One terminal of the lamp is therefore accessible along with the tip and ring for connection to the three-conductor cables. The other terminal of the lamp is connected to battery, and, with the common terminals of the varistors also connected to battery, any varistor can be connected in parallel with any line lamp in the office by means of a single-conductor cross-connection. For offices already in service, the third lead between the main frame and the switchboard is

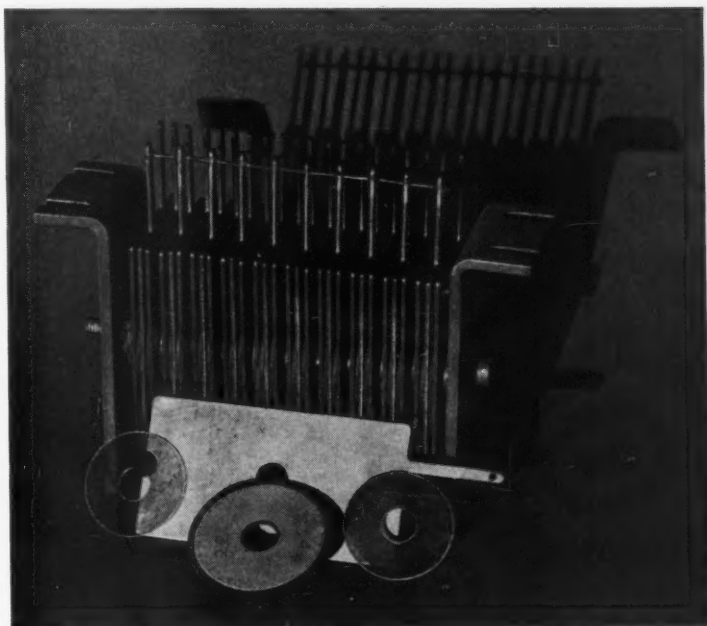


Fig. 2—The 300A varistor for protecting the lamps on twenty subscriber lines

taken care of by adding a separate cable containing one conductor per line for each group of twenty lines on the switchboard.

The battery lead to the varistors is equipped with a three-ampere alarm-type fuse. In general, this has been quite satisfactory. However, this fuse has operated in some offices during

storms of unusual severity, thereby removing the line-lamp protection until the fuse could be replaced. The varistor fusing was changed in a few of these offices to a three-ampere thermal circuit breaker to determine if the slight delay thus introduced in opening the circuit would be sufficient to maintain the varistor circuit closed through heavy surge conditions. To give an indication should the circuit breaker operate, a three-ampere

alarm-type fuse in series with a two-ohm resistance was bridged around the circuit breaker. This combination, under steady-current conditions, is approximately equivalent to a 3.2-ampere fuse, and therefore affords practically the same protection as a three-ampere fuse. This combination has proved very effective in reducing unnecessary circuit interruption for large-current surges, and is now being standardized for general use.

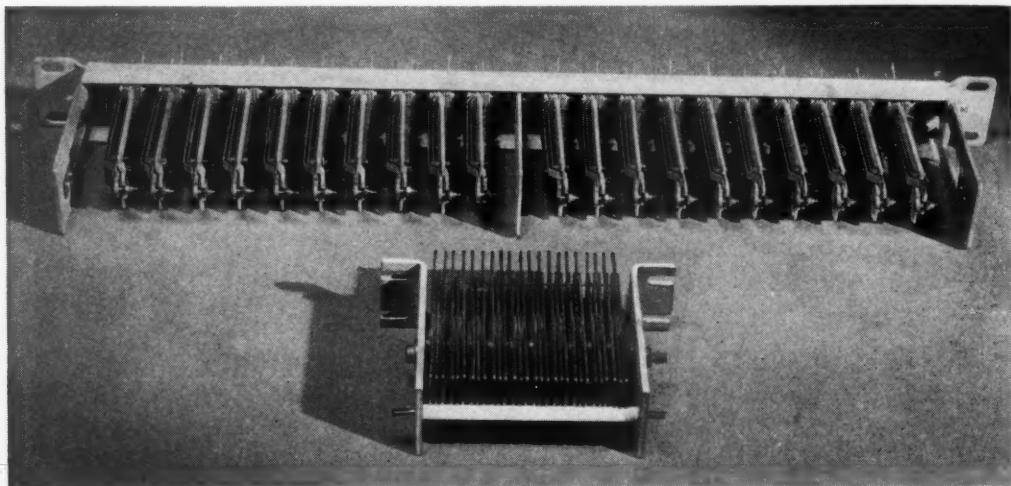



Fig. 3—The 300A varistor unit occupies much less space than twenty line relays



A Broadcast Statement by Walter S. Gifford

IN THESE critical times, national defense is the concern of all of us. Communications are an essential part of national defense and I am happy to report to you, the American people, that your telephone system is, it is generally agreed, by far the most comprehensive and the best in the world. In fact, surveying American industry as a whole, it is encouraging to realize, notwithstanding views to the contrary, that there is greater efficiency under American democracy than under any other form of government.

Your telephone system is the result of initiative and ability, fostered and given free rein in an enterprise privately owned and managed. And today we of the Bell System—and there are more than 300,000 of us—are ready to do our full part in the national defense program. Our business is financially sound. We have the best telephone equipment in the world and we have plenty of it. It has been provided out of the voluntary savings of many hundreds of thousands of men and women. We have a great scientific laboratory, which constantly strives to improve the communication art in which we have always been the leader. Our Western Electric Company, manufacturer of telephone equipment for over 60 years, is our service of supply, with stocks of apparatus and materials in warehouses strategically located throughout the nation. The Laboratories and the Western Electric with their scientific and manufacturing experience are coöperating with the Army and the Navy and the air forces, and are helpful in supplying some of their important needs and in solving some of their important problems. Our telephone construction and maintenance crews are fully mechanized and can be concentrated anywhere quickly. Above all, trained and experienced men and women and the management work together in full coöperation and we are accustomed to plan ahead so that the right material and the right skill will be at the right place at the right time.

It is a real satisfaction to all of us in the Bell System and I feel sure it is to you to know that we can contribute much to the success of the country's national defense—a success which will demonstrate anew the efficiency of American democracy.

"The Telephone Hour," broadcast October 14, 1940.



News of the Month

K-CARRIER EXPANDING RAPIDLY

THE TYPE-K carrier-telephone system for cables is playing a large part in meeting the increased demand for Bell System toll facilities. This demand has been stimulated by recent business improvements and the need for providing a plant that will be adequate for the new defense program.

The total type-K channel mileage in the Bell System plant at the beginning of 1940 amounted to about 100,000 miles. With the completion of this year's program the total will be about 175,000 miles. Among the year's installations are systems from New York to Boston, New York to Pittsburgh, Chicago to Milwaukee and Amarillo to Tucumcari. The latter systems are in a new cable located in a section of the Fourth Transcontinental Route which is in a bad sleet area. The cable is unique in that it will employ at each end a special frequency-converting repeater which will serve to interconnect type-J and type-K systems without

the necessity of bringing the channels down to voice frequencies.

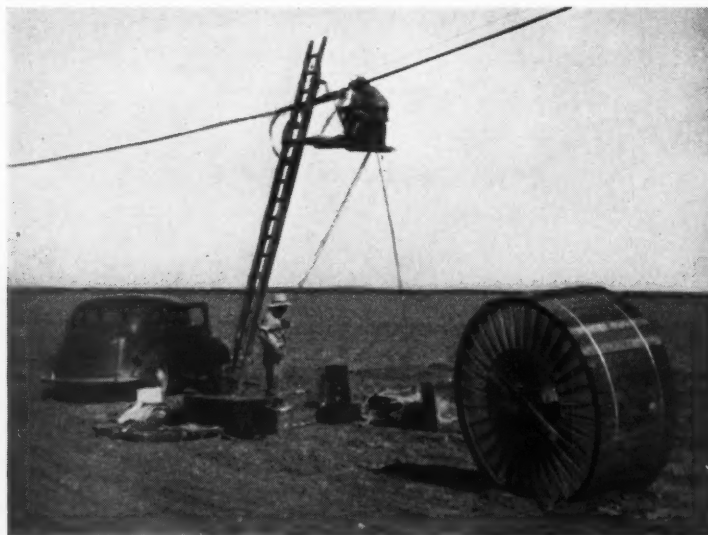
The type-K mileage figures for 1940 seem small in comparison with those contemplated for the next few years. Under present plans the channel mileage will at least double itself in 1941, and make further increases in 1942. Outstanding among the cable projects for these years is the extension of the transcontinental cable from Omaha to Denver.

TALKING THROUGH YOUR HELIUM

A LECTURE AUDIENCE can always be counted on for a laugh when the speaker fills his throat and mouth with helium and talks. His manly tones are replaced by a comedy falsetto, only to resume their original quality as the helium is replaced by air. The helium gas, of density about one-seventh that of air, raises the resonance frequencies of the throat, mouth and nose cavities by a factor of about 2.6, so that they act like cavities of less than half normal size. However, motion pictures taken at 4,000 per second of the vocal cords in an atmosphere of helium show that the cord vibrations are relatively independent of the acoustic load that is formed by the cavities.

The affect of density on acoustic resonance is further illustrated by the observation that the speech of men working under air pressure, such as divers and caisson workers, sounds unnatural. With the advent of stratosphere flying, the effects of rarefied air on speech will probably become more noticeable.

Studies of the speech mechanism are part of the research program of the Laboratories, since the transmission of



J. Mallett making capacity and propagation difference measurements on the Amarillo-Tucumcari cable of the Fourth Transcontinental Route. (Photo by L. B. Hochgraf)

speech is the basic purpose of the Bell System. A thorough understanding of the interactions between the cavities of the vocal tract and the vocal cords is of importance in evaluating other methods of speech transmission than those in current use.

MURRAY HILL

ON THE FIRST of October the steelwork of the main building at Murray Hill was 95 per cent complete, floor arches in the back portion of the building were well under way and exterior brickwork started. About 310 men are now working at the site.

The technical groups that will be located at Murray Hill are the Physical Research Department, the Chemical Laboratories, the Outside Plant Development Department, the Station Apparatus Development Department, and the circuit research groups reporting to A. M. Curtis, E. Peterson and F. B. Llewellyn. The Summit chemical laboratory will be discontinued while the Chester field station will be retained for certain types of work. In addition there will be sufficient representation of Staff Departments to render the necessary services. These include plant operation, general services, personnel and public relations.

COLLOQUIUM

AT THE first meeting of the Colloquium held on October 7, R. R. Williams delivered his retiring presidential address entitled *The Seven Ages of Organic Chemistry*. Mr. Williams traced the rise of the organic branch of chemistry, pointed out the motifs which have prevailed in succeeding eras and appraised the significance of present trends. Success in dealing with natural substances of moderate complexity, which occur only in traces, is considered to be the most conspicuous feature of the recent past; the capacity to deal with macromolecules, which is just now developing, opens even larger opportunities for the next generation.

* * * * *

A NUMBER OF MEMBERS of the Laboratories have been granted leaves of absence to enter military or naval service. Emil Alisch, N. H. Anderson, George Bukur and Einar Reinberg are with the 71st Infantry and P. F. Petersen with the 44th Division Headquarters Detachment of Special Troops,

Fort Dix, New Jersey; W. W. Maas, 102nd Observation Squadron, Anniston, Alabama; R. O. Ford, Ordnance Instructor, Cornell University R.O.T.C.; J. F. Gulbin, 245th Coast Artillery, Fort Hancock, New Jersey; Albert Jost, U.S.S. *Kalb*; and H. W. Kowal, Raritan Arsenal, Metuchen, New Jersey.

THE CONFERENCE on Science, Philosophy, and Religion, held in New York City from September 9 to 11, was attended by R. W.



J. B. Bishop (left) with J. M. Campbell of The Bell Telephone Company of Pennsylvania making field strength measurements on the shore of Delaware Bay near Lewes

King, K. K. Darrow and H. G. Wehe. Dr. Darrow presented a paper entitled *Interplay of Theory and Experiment in Modern Physics*, and participated in a broadcast. Last July Dr. Darrow addressed the Colloquium of the University of California at Berkeley on *The Ionosphere* and the technical staff of the Shell Development Company at Emeryville on *Nuclear Fission*.

C. J. DAVISSON attended a reception, held at the New York World's Fair on September 25, in honor of Dr. Gerald Wendt, retiring director of science and education at the Fair.



DR. J. S. WATERMAN

JOHN SLATER WATERMAN, M.D., for the past twenty-three years Medical Director of the Laboratories, retired from active service on the thirty-first of October. Dr. Waterman received his professional degree from Harvard University in 1901 and for the next year was resident surgeon at the Free Hospital for Women in Boston. From 1902 to 1907 he was with the Boston City Hospital, first as an interne and then as resident surgeon for its Relief Station. He was in private practice at Providence from 1907 to 1915 and was for two years in charge of industrial surgery in a hospital at Rome, New York. He then joined the Engineering Department of the Western Electric Company.

During the twenty-three years which followed, Dr. Waterman assumed a unique relationship to members of the Laboratories. Through physical examinations both at entrance and later, he came to know them widely and deeply. To some he gave the reassurance of an independent diagnosis: a pain didn't always require an operation to cure it. To others he spoke firmly and they went to bed before a cold devel-



F. A. VOOS

oped into pneumonia. Sometimes a quiet talk in Dr. Waterman's office proved that an illness, on its face physiological, had an emotional origin. There his kindly interest and sound counsel proved invaluable in guiding the patient toward a cure.

* * *

F. A. Voos of the Switching Apparatus Development Department retired from active service on the thirty-first of October. Mr. Voos, after a number of years of machine shop and toolroom work with various

companies, became a tool designer in 1902 for the Crocker Wheeler Electric Company, changing later to the Bullock Electric Company in Cincinnati and then the Otis Elevator Company in the same capacity. From 1908 to 1910, he was with the Weston Electrical Instrument Corporation, designing special electrical measuring instruments. During the time he was with this company he was also engaged in the development of remote-control firing equipment for artillery which led to his employment by the United



I. H. HENRY

of the Switching Development Department completed thirty years of service in the Bell System on October 14



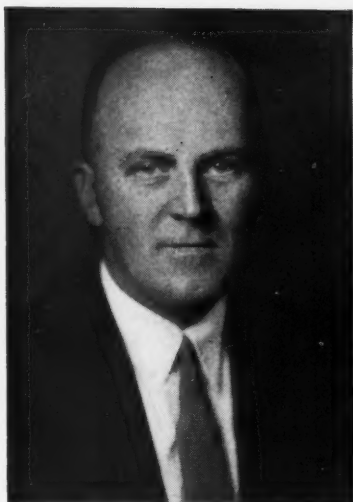
H. G. RIFE

of the Outside Plant Development Department completed thirty years of service in the Bell System on October 10



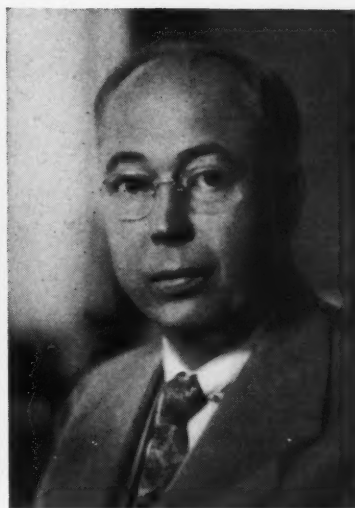
G. B. HAMM

of the General Service Department completed forty years of service in the Bell System on October 15



C. H. WHEELER

of the Switching Apparatus Development Department completed thirty-five years of service on October 26



LLOYD ESPENSCHIED

Consulting Engineer of the Laboratories completed thirty years of service in the Bell System on October 20

States Government at the Sandy Hook proving grounds where he prepared range charts for heavy coast artillery.

Mr. Voos joined the machine switching group of the Western Electric Company's Engineering Department in 1912. He took part in the original development of the panel apparatus subsequently installed in the semi-mechanical offices in Newark, and of the call-distributing type in Wilmington. From 1919 to 1925 he was engaged in the design and application of tools and gauges for the maintenance of panel-type office equipment. After a short interlude in the Physical Laboratories, mainly in the testing of panel apparatus, Mr. Voos became associated with the development of step-by-step and then crossbar apparatus. For the six years previous to his retirement he had been concerned with the design and development of calling dials in the Switching Apparatus Development Department. Mr. Voos had been very active in the Bell Laboratories Chess Club of which he was a mainstay and an outstanding player.

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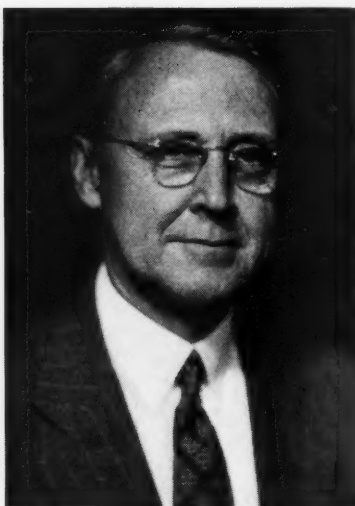
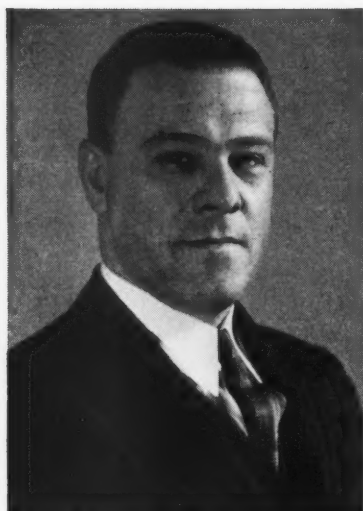
REGULAR TELEPHONE SERVICE between the United States and Spain, suspended since the outbreak of the Spanish civil war in 1936, was restored on October 22 with the

opening of a direct short-wave radio circuit between New York and Madrid. Previously calls were routed over New York-London radio channels and completed over cable and wire lines. The new channel also becomes the normal route to Portugal, which at present is reached via Rome and Berlin.

MEETINGS OF THE American Chemical Society in Detroit were attended by R. R. Williams, H. G. Arlt, W. O. Baker, C. J. Christensen, W. G. Guldner, J. H. Ingmanson, A. R. Kemp, C. L. Luke, M. L. Selker, W. G. Straitiff, G. T. Kohman, and L. Egerton. A paper by C. S. Fuller, *Crystalline Behavior of Linear Polyamides*, was presented by Mr. Baker. Following the presentation of a paper on a new method for the determination of moisture, Mr. Kohman and Mr. Egerton participated in a roundtable discussion of the method with representatives from the du Pont and General Electric Companies.

THE GEOPHYSICAL LABORATORY in Washington was visited by R. R. Williams, W. L. Bond and S. O. Morgan of the Laboratories and C. R. Avery of Western Electric.

H. W. HERMANCE and H. V. WADLOW visited an unattended community-dial office in Church Hill, Maryland, in an investigation of corrosion problems.



V. H. HEITZMANN

of the Station Apparatus Development Department completed thirty years of service on September 16

H. C. CAVERLY

of the Switching Development Department completed forty years of service in the Bell System on September 17

G. W. WEAVER

of the Switching Development Department completed thirty-five years of service in the Bell System on September 18

AT THE ROCHESTER MEETING of the Optical Society of America, held from October 3 to 5, H. E. Ives and G. R. Stilwell presented a paper entitled *Interference Phenomena with a Moving Medium*, and H. B. Briggs a paper entitled *A Supersonic Cell Fluorometer*.

THE PAPER, *Ultra-Short-Wave Transmission Over a 39-Mile "Optical" Path*, by C. R. Englund, A. B. Crawford and W. W. Mumford, presented before the annual convention of the I.R.E. in Boston last June, was published in the August issue of the Institute's *Proceedings*.

ON SEPTEMBER 24, F. H. Willis with A. F. Blunt, C. F. Bohnet and E. T. Loane of The Chesapeake and Potomac Telephone Company inspected sites for ultra-high-frequency radio-telephone stations proposed to give service to islands in the lower Chesapeake Bay.

* * * * *

THE PRESENTATION of a five-star emblem to H. D. Peckham on the third of September signified his completion of a quarter-century of service in the Western Electric Company and the Laboratories. After attending Brooklyn Polytechnic Institute, Mr. Peckham joined the repeater laboratory of the Western Electric Engineering Department

as a draftsman in 1915. A year later he transferred to circuit design work on the No. 1 toll-test board, repeaters and carrier equipment and subsequently he had charge of the manual circuit laboratory. Early in 1922 Mr. Peckham organized the service group for the radio development laboratory and then spent some time writing specifications and handling trial installations in the Equipment Development Department.

In 1923 Mr. Peckham transferred to the Commercial Service Department and since then has been supervising the analysis of Laboratories expense billable through the Western Electric Company to its customers. Mr. Peckham has been very active in the Bell Laboratories Club. In this connection he has written, composed and directed several of the shows given by the Club and also directed the Glee Club for two years.

* * * * *

P. W. SHEATSLEY of the Switching Engineering Department completed twenty-five years of service with the American Telephone and Telegraph Company and the Laboratories on the tenth of September. He graduated from Ohio State University in 1915 with the degree of B.M.E. From 1910 to 1914 he also worked for the Columbus (Ohio) Railway, Power and Light

Company where he gained valuable experience in the generation and distribution of electric power. Mr. Sheatsley joined the Engineering Department of the American Telephone and Telegraph Company in 1915 and assisted in determining the requirements for and coöperating in the development of telephone central-office apparatus and equipment.

When the Department of Development and Research was formed in 1919 Mr. Sheatsley continued this type of work in the equipment development group of this Department. He made many contributions in the development of frame and rack equipment for the panel system; main distributing frames for terminating underground cables in the larger multi-unit central-office buildings; lighting standards for local and toll offices; and fire protective equipment and methods for central-office use. When the D and R was consolidated with the Laboratories in 1934, Mr. Sheatsley joined the Local Central Office Facilities Department, now the Switching Engineering Department, where he has since been engaged in the development of both manual and dial central-office equipment.

* * * * *

ON THE SIXTEENTH of September A. R. Bonorden completed twenty-five years of service in the Bell System. From 1912 to 1920 Mr. Bonorden worked an aggregate of nearly five years with The Pacific Telephone and Telegraph Company

and the Western Electric Company in San Francisco and Oakland installing PBX and station systems, shop wiring of magneto and common-battery central offices, switchboards, and on the maintenance of manual and toll central offices. During this period he also obtained an engineering education at the University of California from which he received an A.B. degree in 1920. Following his graduation he again joined the Pacific Company and spent the next seven years in engineering central-office equipment additions, the preparation of economic cost studies involving the application of new Bell System developments including straightforward trunking in the local and tandem systems in the San Francisco Bay area and in the design of circuits and the preparation of manufacturing information where standard circuits and equipment would not apply. Among the specific projects with which he was associated were the complete engineering of call-indicator trunk and dial equipment, additions in all manual offices in Portland, Oregon, and of several DSA boards in Los Angeles as part of a program for consolidating the manual and step-by-step dial systems in these cities.

In 1927 Mr. Bonorden transferred to the equipment development section of the Department of Development and Research of the American Telephone and Telegraph Company. Here, in the local central-office group, he was concerned with the investigation of economic equipment and circuit



H. D. PECKHAM



P. W. SHEATSLEY



A. R. BONORDEN



arrangements, the determination of final design requirements, and the study of possible improvements in subscriber senders and decoders of the panel dial system. He transferred to the telegraph group in 1932. Since 1934, when the D & R merged with the Laboratories, Mr. Bonorden has been responsible for the investigation of arrangements and methods for economically supervising private-wire telegraph service and for maintenance of central-office TWX equipment. This has included the preparation of design requirements of the No. 1 telegraph service board, an initial installation of which is now in successful operation at Dayton, Ohio.

His contributions to the telephone industry include a coin-box mechanism for handling 5- and 10-cent zone calls, a cordless TWX switching system, a telegraph concentration arrangement now in use in one of the large press association offices and a system of inter-office telegraph and telephone trunks permitting cordless transfer of calls at telegraph test boards.

* * *

J. A. BECKER spoke on *Varistors and Some of Their Uses* at the October 4 meeting of the Radio Colloquium held at the Holmdel radio laboratory.

MEMBERS OF THE LABORATORIES who are on the 1940-1941 committees of the American Institute of Electrical Engineers include the following: *Code of Principles of Professional Conduct*, F. B. Jewett; *Charles LeGeyt Fortescue Fellowship*, O. E. Buckley; *Iwadare Foundation*, F. B. Jewett; *Lamme Medal*, M. J. Kelly; *Board of Examiners*, H. S. Warren; *Headquarters*, O. B. Blackwell; *Publication*, S. P. Shackelton; *Research*, M. J. Kelly; *Standards*, R. L. Young and R. G. McCurdy; *Basic Sciences*, M. J. Kelly and J. D. Tebo; *Communication*, H. A.



With thirty-nine individuals participating and with over two hundred and fifty exhibits, the First Annual Flower Show of the Bell Laboratories Garden Club was an unqualified success. The photograph above shows, left to right: E. G. D. Paterson, chairman; C. E. Lane and H. G. Romig of the committee. Other members of the committee were Miss H. B. Mayhew and H. M. Pruden. The photographs on the opposite page show a portion of the flowers exhibited

Affel and John Davidson, Jr.; *Education*, R. I. Wilkinson; *Instruments and Measurements*, W. J. Shackelton; *Protective Devices*, A. H. Schirmer; *Power Transmission and Distribution*, H. M. Trueblood; and a special committee on *Biographies and Talking Motion Pictures*, R. L. Jones.

E. B. WHEELER visited the National Carbon Company's plants in Cleveland and Fremont, Ohio, on September 17 and 18 to discuss dry battery problems. He also visited the Ken-Rad Lamp Works in Owensboro, Kentucky, on September 23 to observe their manufacture of lamps.

E. B. WOOD and R. T. STAPLES visited Point Breeze to discuss cord problems.

NEW NETWORK assemblies proposed for standardization were discussed by H. Whittle, F. J. Hallenbeck and H. M. Thomson at Kearny.

THERE ARE NOW 173 transcontinental telephone circuits on the four different routes to the Pacific Coast. Of these, 22 circuits are on the Northern Transcontinental Line, 43 on the Central, 31 on the Southern and 77 on the Fourth.

C. ERLAND NELSON was in Buffalo to study panel-bank contacts.

H. E. DeCAMP of the Hawthorne plant of the Western Electric Company visited the Laboratories to discuss various questions in connection with crossbar apparatus.

J. R. TOWNSEND attended the Standards Committee Meeting of the American Society for Testing Materials in Philadelphia.

W. J. TIETZ and R. A. CRAIG of the Hawthorne plant of the Western Electric Company visited the Laboratories to discuss selectors and step-by-step equipment.

LECTURES BY H. Nyquist on *Theory* and J. F. Morrison on *Transmitters* form part of the course on the subject of frequency modulation which is being presented by the Communication Group of the New York Section of the A.I.E. The series began on October 14 with a large number of Labora-

tories engineers in attendance. E. I. Green is a member of the committee in charge of the arrangements.

ON JUNE 30, 1940, there were 96,950,000 miles of telephone wire in the United States. The Bell System had 87,197,000 miles, 60.8 per cent of which was in underground cable, 33.9 per cent in aerial cable and 5.3 per cent in open-wire lines.

DURING THE THIRD QUARTER of 1940, the following Laboratories employees have been enrolled as members of the Telephone Pioneers of America:

Beyer, J. W.	MacColl, L. A.
Burns, R.	Mattice, Miss C.
Corwin, J. W.	Miller, A. S., Jr.
Dustin, G. E.	Miller, C. G.
Getz, E. L.	Mohr, F.
Glaser, G. L.	Price, H. S.
Goehner, W. R.	Pruden, H. M.
Hoyt, L. G.	Schucht, H., Jr.
Jaycox, E. K.	Schupp, Mrs. M. J.
	Shafer, J. E.

FIELD TRIALS of new buried cable coverings were observed at Poquoson, Virginia, on September 10 by R. P. Ashbaugh, R. A. Haislip and W. E. Mougey.

J. H. GRAY spent several days in Maryland on an investigation of buried cables.

H. BAILLARD and M. W. BOWKER have been in Baltimore on splicing operations involved in the Baltimore-Washington cable installation.

ON SEPTEMBER 24, A. B. Clark, R. A. Haislip, R. L. Jones, R. G. McCurdy, W. E. Mougey, D. A. Quarles, and M. E. Strieby of the Laboratories and J. J. Pilliod and J. W. Campbell of the A. T. & T. were in Baltimore to confer with engineers of the Western Electric Company on the manufacture of coaxial and other new types of broad-band



With clenched pipes these younger members of the Laboratories imitate their elders in the Club Room during noon hour. Left to right: Kenneth Forrestal, messenger; George Richards, technical assistant in the Outside Plant Development Department; Aksel Skaaland, clerk in messenger service; and Howard Schantz, clerk in mailing department

cable. They also observed some of the operations of plowing in a portion of the new Baltimore-Washington cable which contains both coaxials and pairs for type-K carrier operation.

T. A. DURKIN was in Eau Claire, Wisconsin, with engineers of the Long Lines Department, studying gas-flow characteristics of coaxial cables.

C. H. AMADON and G. Q. LUMSDEN inspected experimental ground-line treatments of poles in service in the Port Jervis-Monticello line. Mr. Amadon also inspected poles in line in the vicinity of Palmyra, New York, and demonstrated ground-line treatment with creosote and sodium fluoride.

D. T. SHARPE was in Baltimore in connection with supply arrangements for desiccants used for cable splicing and maintenance.

J. W. KENNARD of the Outside Plant Development Department's group at Point Breeze went to Columbia, Maryland, for tests on the new Baltimore-Washington cable.

AT THE HAWTHORNE plant of the Western Electric Company, G. M. Bouton, C. H. Greenall, and F. B. Livingston discussed the application of lead-calcium sheathing alloy to small-size cables; P. S. Darnell and R. A. Ogg, the manufacture of resistances and problems relating to the introduction of new flat-type resistance designs; E. L. Fisher and C. Schneider, coil manufacturing methods and practices; M. Fritts, design of terminal strips; C. L. Van Inwagen, methods of producing improved step-by-step banks; I. V. Williams, problems of heat treating steel; and J. E. Shafer, the manufacture of the three-position polarized relay for two-party message rate service.

W. M. BACON was in Schenectady on September 27 and 28 to observe the operation of the private-wire teletypewriter switching system at the General Electric Company.

H. W. HEIMBACH has been elected a member of the Bernards (New Jersey) Township Board of Education.

AT BOSTON, J. G. Ferguson, A. S. King and P. Winsor, Jr., discussed step-by-step equipment with engineers of the New Eng-



T. C. Rice kibitzes the bridge of E. W. Waters and E. C. Matthews. In 1931 Mr. Rice, in the early years of contract bridge at the Laboratories, taught the first class in the game. Since then all three men have been active in the Bell Laboratories Bridge Club and in the Metropolitan Bridge League

land Telephone and Telegraph Company.

R. C. JOHNSON inspected an installation of a new distributing frame for mounting protectors and filters at the McLean central office of The Chesapeake and Potomac Telephone Company of Virginia.

S. J. BRYMER with engineers of the Installation Department of the Western Electric Company visited Lock Haven, Pennsylvania, where a No. 3CF switchboard is being installed for The Bell Telephone Company of Pennsylvania.

J. H. SOLE discussed the design of power plants with manufacturers in Fort Wayne and Cleveland.

V. T. CALLAHAN was in Canton, Lansing and Minneapolis, to confer with manufacturers on the design of reserve engines.

A. E. PETRIE discussed general power questions with engineers of the Operating Companies in Cleveland, Chicago and



ERNEST HARMS, 1879-1940



W. J. LACERTE, 1899-1940

W. J. LACERTE of the Switching Development Department who had been with the Laboratories since 1923 died on October 12. Mr. LaCerte received his B.S. degree in Electrical Engineering from Kansas University in 1923 and immediately joined the dial system laboratory group of the Systems Development Department. For a few years he was engaged in laboratory testing of circuits for dial offices and private branch exchanges and later, in what is now the field development group of the Switching Develop-

ment Department, he conducted studies in the field on trial installations of circuits of these types. Since June of 1937 Mr. LaCerte had been concerned with the field work associated with the introduction of the cross-bar system in the Associated Companies' territories, the most recent being in Washington for the Chesapeake and Potomac and in Chicago for the Illinois Bell.

Minneapolis. He also inspected the power equipment of the Stevens Point-Minneapolis coaxial cable.

H. M. SPICER was in Boston on power-switching problems.

D. E. TRUCKSESS visited an installation of a regulated tube rectifier of the New England Telephone and Telegraph Company at Booth Bay Harbor, Maine.

C. R. ECKBERG recently supervised the installation of coaxial terminal equipment installed at Stevens Point and Minneapolis.

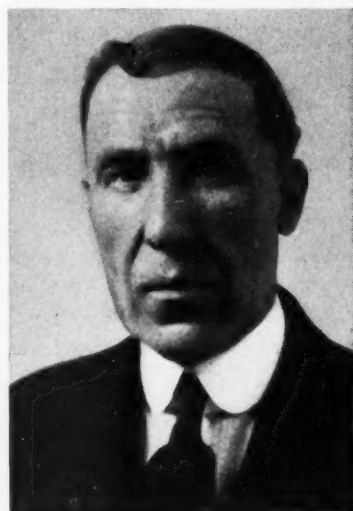
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ERNEST HARMS of the Plant Department, who retired on April 15 following twenty-five years of service in the Western Electric Company and the Laboratories, died on the twenty-ninth of September. Mr. Harms joined the Western Electric Company in 1915 as a boiler-room helper. A year later he became an oiler on steam engines where he remained until 1923 when the generation of electric power was discontinued. From then until the time of his retirement he had been engaged in various kinds of work in the power service group of the Plant Department.

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F. E. KEEFE, 1904-1940



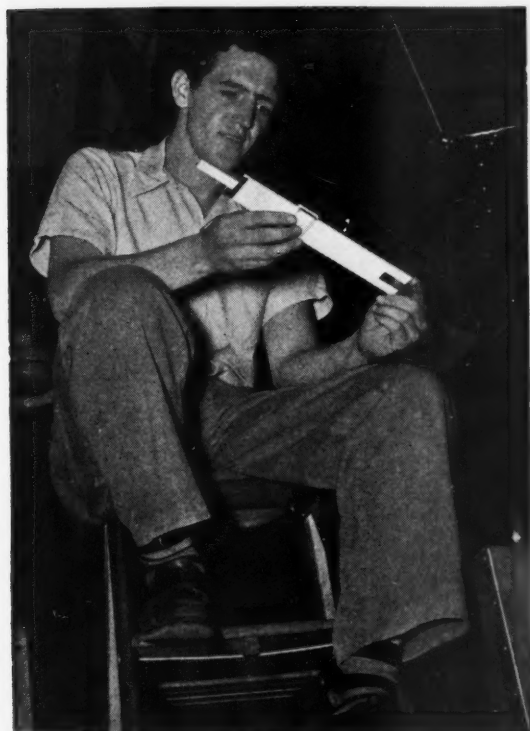
JAMES BRYSON, 1878-1940

November 1940

Service Department in 1930 as a laboratory service attendant and was located in the Graybar-Varick building.

* * * * *

JAMES BRYSON of the Shipping Department, with twenty-two years of service in the Western Electric Company and the Laboratories, died suddenly on the twenty-ninth of September. After several years' experience as a stock clerk and shipping clerk, in 1918 he joined the Western Electric Company as a packer. He was placed in charge of the Shipping Department in 1927. Mr. Bryson was extremely resourceful in devising clever means for packing delicate



C. C. Cutler of the Deal radio laboratory makes a slide-rule computation as he observes a temperature test on the short-wave condenser

apparatus and during the time that he was in charge of the Shipping Department no damage claim was entered due to faulty packing. Last fall when Homer Dudley demonstrated speech synthesis before groups in Detroit, Chicago, St. Louis and Iowa City, Mr. Bryson accompanied him to take care of the packing and transportation of the equipment used.

November 1940

W. A. MACMASTER visited the coastal harbor radio-telephone stations at Lake Bluffs, Illinois, and Loraine, Ohio. He also discussed with the engineers of the Michigan Bell Telephone Company plans for harbor radio stations at Detroit and Port Huron.

A. B. S. KVAAL attended the annual meeting of Technical Drawing Associates held at



R. F. Lane of the Radio Development Department working on a 32A radio range receiver in the Graybar-Varick building

the Westinghouse Electric and Manufacturing Company, Pittsburgh.

L. H. ALLEN visited Detroit to demonstrate new station facilities to the Michigan Bell Telephone Company.

J. H. SHUHART went to Denmark, South Carolina, to consult with engineers of the Long Lines Department on crosstalk tests on open-wire circuits rebuilt to provide new type-J system assignments between Charlotte and Miami.

E. D. GUERNSEY, in Colorado, made a coöperative study of the inductive influence of rural power circuits, and of noise, on exposed lines of The Mountain States Telephone and Telegraph Company. He was accompanied by engineers of the Rural Electrification Administration.

R. M. HAWEKOTTE, accompanied by H. W. Wahlquist of the Edison Electric

Institute, has been engaged in a coöperative inductive coördination study in Long Island involving lines of the New York Telephone Company.

DURING THE MONTH of October the following members of the Laboratories completed twenty years of service in the Bell System:

Apparatus Development Department

S. J. Zammataro

Systems Development Department

I. W. Brown

J. B. Newsom

R. M. Pease

General Service Department

N. L. LaMattina

Plant Department

P. J. Doorly

John Mogilski

Miss Bertha R. Mohl

DURING SEPTEMBER, M. T. Dow, R. R. Hough, J. Mallett, H. B. Noyes, H. W. Nylund, E. S. Wilcox and Miss E. Rentrop of the Laboratories and L. G. Adam of the Long Lines Department were in Texas to begin a series of noise and crosstalk tests on the new cables being installed for type-K

operation between Amarillo, Texas, and Tucumcari, New Mexico. R. P. Booth and A. G. Chapman visited Adrian, Texas, to consult with the engineers engaged in these tests. L. B. Bogan of the O. & E. also spent some time in Texas in connection with this project.

AT HAZLETON, PENNSYLVANIA, W. W. Sturdy, E. D. Sunde, R. W. Gutshall, J. J. Mahoney and Miss E. M. Baldwin spent three weeks during which they made surge tests on the aerial toll cables between Reading and Wilkes-Barre.

SURGE TESTS on local aerial cable and associated open-wire lines made over a period of five weeks in the vicinity of Springfield, Massachusetts, have been completed and W. W. Sturdy, L. K. Swart, R. W. Gutshall, D. W. Bodle and Miss E. M. Baldwin have returned to New York. Special demonstrations of tests and equipment were given for representatives from various divisions of the New England Telephone and Telegraph Company.

THE STEVENS POINT-MINNEAPOLIS coaxial installation was a center of activity for



Last year over 400 dolls were dressed by members of the Laboratories and their families and over 1500 dolls and toys were purchased through the committee for the less fortunate children of Metropolitan New York. This generous response has encouraged the women of the Laboratories to repeat this activity in 1940. The Doll and Toy Committee consists of Edna Aamodt, chairman Grace Clifford, Olga Gramm, Marie Grent, May Hale, Ruth Harrington, Marguerite Johnston, Marion Kane, Margaret McEntee, Helen Mockler, Louise Muller, Helen Raczy, Mary Reddington, Dolorita Shevlin and Louise Van Bergen



H. Walther and E. G. Andrews of the Bell Laboratories Chess Club get in a practice game in the Club Room

many engineers during the past month. H. H. Benning, B. Dysart, M. M. Jones, and B. H. Nordstrom continued tests in lining up the circuit and arranging the proper equalization. R. P. Jutson has been engaged in work on power supply. G. B. Engelhardt, K. E. Gould, F. A. Janiszewski, and T. M. Odarenko made measurements of characteristics which will be important in forthcoming tests of television transmission. T. C. Henneberger and W. C. Ball visited the installation in connection with dielectric strength tests and fault-location problems. V. M. Meserve and F. E. DeMonte have spent some time at Minneapolis and Stevens Point working on the coaxial terminals.

SEVERAL TRIPS to Kearny were made by R. R. Blair, M. E.

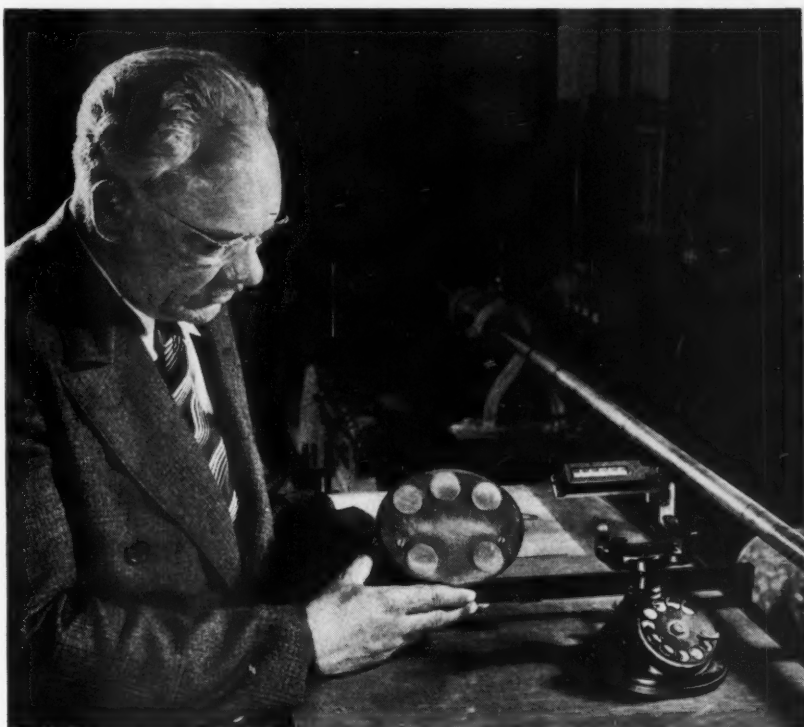
Campbell, B. J. Kinsburg, and L. H. Morris in connection with the production of coaxial repeater equipment. Mr. Blair also spent a day at Holmdel discussing silicon detectors.

C. F. BOECK and C. J. CUSTER made trips to Princeton and Philadelphia to make tests on the New York-Philadelphia coaxial system, which is now being used for certain television experiments.

AT THE HAZELTINE SERVICE CORPORATION in Little Neck, Long Island, D. A. Quarles, A. G. Jensen, M. E. Strieby and C. L. Weis conducted certain television studies.

J. P. RADCLIFF spent a day in Philadelphia in connection with removal of some of the testing equipment that had been employed in the New York-Philadelphia coaxial trial.

W. E. REGAN spent all of August in



W. A. Krueger observes the wear of the material on the base of a subscriber's set which has been tested by dragging it back and forth on a smooth board to simulate pushing the set on a desk. The reciprocal motion of this testing apparatus amounts to a mile an hour

Boston working on the New York-Boston compandor trial.

THE PRODUCTION AND TESTING of carrier equipment were reviewed at Kearny with engineers of the Western Electric Company by H. A. Affel, E. I. Green, H. J. Fisher, S. W. Shiley and B. R. Blair.

THE LABORATORIES were represented in interference proceedings at the Patent Office in Washington by O. D. M. Guthe before the Primary Examiner and by F. Mohr before the Examiner of Interferences.

THE FOLLOWING MEMBERS of the Laboratories have been appointed as committee members of the Edward J. Hall Chapter of the Telephone Pioneers of America for the 1940-1941 year: Executive Committee, W. Wilson and G. D. Edwards; Membership Committee, R. J. Heffner, Chairman; R. A. Shetzline and H. J. Delchamps; and Entertainment Committee, W. A. Bollinger and E. D. Johnson.

F. D. LEAMER attended the Seminar Course in Industrial Relations conducted at

the Graduate College of Princeton University from September 11 to 14.

D. D. HAGGERTY attended the Congress of the National Recreation Association at Cleveland, September 30 to October 4, to discuss programs and problems with the recreation directors of other industrial organizations.

PATENTS WERE ISSUED to the following members of the Laboratories during the month of September:

H. W. Augustadt	R. J. Kircher
W. Bennett	H. K. Krist
W. R. Bennett	R. C. Mathes
H. C. Caverly	D. Mitchell
H. W. Dudley	N. Monk
F. Gray	E. Peterson (3)
E. I. Green	H. T. Reeve
E. F. Kingsbury	H. N. Wagar

AN ARTICLE entitled *Results of the World's Fair Hearing Tests*, by J. C. Steinberg, H. C. Montgomery and M. B. Gardner, was published in the October issue of *The Journal of the Acoustical Society of America*.



Rear view of the channel-terminal bays for twelve type-K carrier-telephone systems together with their carrier supply bays as they appear in the Long Lines building at 32 Sixth Avenue

Wire-Joining Methods

By J. B. DIXON

Outside Plant Development

EARLY telephone lines on poles were commonly joined by twisting the two conductors together and wrapping the free ends closely about each other, but prior to 1906 this method gave way to joining with sleeves of copper or steel. The ends of the wires were inserted in two parallel bores and the assembly was twisted with tools known as sleeve twisters. This joint was a substantial improvement over the previous one because it was stronger and the sleeve afforded some corrosion protection to the joined ends. For many years, this twisted connection gave acceptable service on copper and steel lines as well as on insulated wires such as inside wire, drop wire and bridle wire.

With higher standards of transmission, and particularly the introduction of carrier frequencies, resistance unbalances were experienced in open-wire lines which were attributable to variable resistance in the twisted sleeve. These unbalances were generally small for each individual sleeve, but the accumulation of many such irregularities in a long line caused an excessive unbalance for circuits requiring high-quality transmission. It was also difficult to identify faulty joints because the very thin films of corrosion products, which were generally responsible for the trouble, broke down quite readily if the lineman moved the wires, or were

even eliminated by the relatively low voltages used in testing. As a remedial measure sleeve joints were soldered or renewed. In existing joints a small hole was filed through the shell near the end of each sleeve, so that the soldering could be done where the wire was not under tension. In making new joints the free ends of the two wires were left sufficiently long to permit bringing them together and they were then soldered to insure permanently low resistance. These methods confined the heating caused

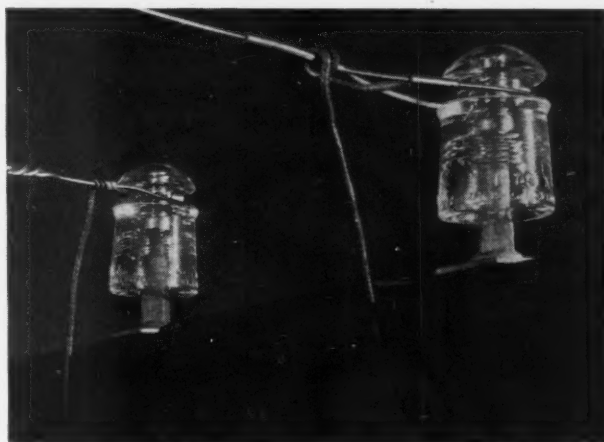


Fig. 1—Dead ends on open-wire lines are made by looping half-round wire around the insulator and bringing the flat surfaces together in a single sleeve

by soldering to sections of the hard-drawn line wires where the unavoidable annealing did not adversely affect the strength of the line. They were effective in overcoming the unbalance but the operations involved were costly.

To correct this condition the Lab-

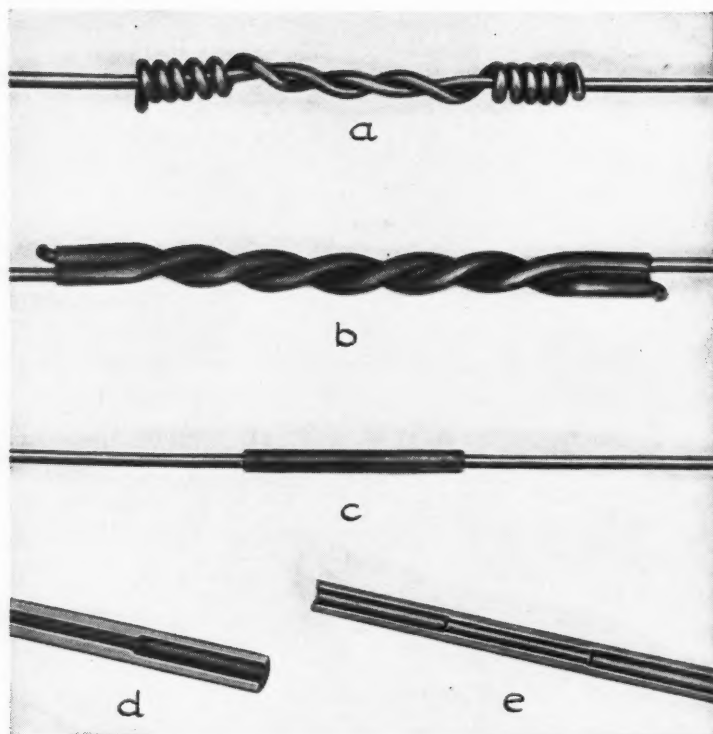


Fig. 2—Joints used on open-wire lines: (a) "Western Union" joint used before 1906, (b) twisted sleeve joint, (c) new rolled sleeve joint, (d) section of a sleeve for making dead ends and (e) section of a steel "maintenance" sleeve for joining steel wires, one of which has been reduced in size by corrosion

atories developed in 1927 an improved wire joint which eliminated troubles caused by corrosive action. The new method is used primarily for joining open wire and drop wire and may have substantial applications in other telephone plant wiring such as for joining cable conductors in lead-covered cable. Single tubes are used as sleeves to form a butt instead of a lap joint, such as was made with the two-bore twisted sleeve. The sleeves are applied on line wire with a small hand-operated rolling mill* which forces them under high pressures into intimate contact with the wire. Joints made with this tool provide a gas-tight union between the wire and sleeve which effectively

*RECORD, Nov., 1931, p. 74.

seals against corrosion. Many millions are now in service and no instance of corrosion within the sleeve has been reported.

In joining small-sized conductors, as in drop and station wiring, rolled joints are satisfactory but the sleeves are more conveniently applied with a small pressing tool because the work of constricting small sleeves is much less than for large ones and the joint frequently has to be made in inconvenient locations such as out-of-the-way corners and shafts.

To obtain optimum holding power in joints on wires strung in spans, a lacquer and emery coating is applied to the bores of the sleeves. The emery particles are imbedded in the wire and the sleeve when compressed forms an effective interlock. This increases the resistance to slippage. For copper line wires, the sleeves are made from soft copper tubing, which is readily rolled and develops adequate strength. Mild steel tubes, with the outer surfaces protected by a heavy coating of zinc, are used to join steel line wires. Annealed brass sleeves are used to join the conductors of insulated wires, because brass is preferable to copper for contact with rubber compounds. The higher strength of the brass is also advantageous when the wires are under tension.

Wires of different diameters are joined by a "combination" sleeve

which is like the one previously described except that the bore of each half is of different diameter. "Maintenance" steel sleeves are also provided for joining steel line wires whose diameters have been reduced by corrosion. This sleeve has two progressively smaller bores in tandem at one end to accommodate the corroded wire and a single bore at the other end for new wire.

Rolled sleeve joints have been adapted for dead-ending open-wire lines by looping a short length of half-round wire around the insulator and bringing the flat surfaces together in one end of the sleeve; the line wire is held in the other end. This loop develops the full strength of the line wire, after the joint is rolled, and its use simplifies material and tool stocks by eliminating entirely the double tube sleeves and sleeve twisters that were previously used.

Where open wire is dead-ended, the circuit often has to be extended to terminals through a length of insulated conductor. Heretofore, these two types of wire were joined by soldering or the insulated wire was attached to the line wire by a "bridging connector." For making "bridge" joints, where they do not have to be disconnected for testing, a rolled sleeve has been developed with two parallel bores. One accommodates the half-round dead-ending wire

and the other the conductor of the insulated wire. This sleeve has a soft copper core enclosed in copper tubing. To make the connection, the half-round wire is pulled through the



Fig. 3—Rolling the sleeve to the wires with a rolling tool

sleeve before the dead-end loop is completed; the insulated conductor is then placed and the sleeve rolled.

These new rolled joints reduce maintenance costs considerably by eliminating high-resistance joints and improving holding power. With them wire failures can sometimes be repaired without cutting in slack.



A Bridge for Measuring Core Loss

By H. T. WILHELM
Electrical Measurements and Design

Because of its precision, the a-c impedance bridge has been generally used in the Bell System for core-loss measurements. A coil of wire is wound on the material being investigated, and the resistance of the coil is measured with the bridge. This measured value includes the d-c resistance of the coil as well as the core loss. The d-c resistance, however, can be determined separately, and by subtracting it from the total effective resistance, the core loss remains. There is also a small resistance component due to the "skin effect," but this also may be determined separately and deducted, and need not be considered here.

If the core loss is large relative to the d-c resistance, the precision with which it can be measured is of the same order of magnitude as that of the bridge itself, while if it is small relative to the d-c resistance, the precision attained is much less than that of the bridge.

This condition is well illustrated in Figure 1. Here R_e is the total effective resistance, and the d-c resistance, R_{dc} , is subtracted from it to give the core loss ΔR . The total error in the measurement of R_e thus remains as an error in ΔR . Where ΔR is large compared to R_e , as is true for poor core material indicated at the left, the percentage error of ΔR is about the same as that of R_e , but where ΔR is small compared to R_e , as for the good core material

WHENEVER a varying magnetic flux is set up in magnetic material, various losses occur that are grouped together under the name core loss. In power work, these losses are large, and are measured in watts. In communication work, however, the actual amount of power wasted is usually negligible, but the effects of core loss on transmission are of the utmost importance in high-quality apparatus and circuits. They have the effect of increasing the effective resistance of the apparatus by an amount that varies with the strength and frequency of the component signals, and thus they result in distortion. Considerable work has naturally been done in the Bell System to devise methods of measuring core loss and to develop materials in which the core loss is a minimum.

shown at the right, the error becomes a much greater per cent of ΔR than it was of R_e .

In any such bridge measurement, the reactance component must be balanced as well as the resistance component, and in a high-quality coil the reactance may be more than 100 times the value of the resistance. This ratio becomes greater as the coils are improved because the quality of a coil, known as its "Q" value, is equal to the ratio of the reactance to the resistance. This fact also increases the difficulty in securing precise measurements of core loss of high-quality coils because the larger Q becomes, the more difficult it is to determine a small resistance component with any degree of accuracy.

The ratio of the voltage impressed across a coil to the current that flows in it is the impedance, which in Figure 1 is represented by the vector z . The angle between the impedance and reactance vectors is the loss angle of the coil, and the tangent of the loss angle, R_e/x , is the reciprocal of Q. For small angles, such as the loss angles of ordinary communication coils, the tangent is equal to the angle measured in radians; and thus a coil with a Q of 100 has a loss angle of 0.01 radian or 10 milliradians. Since part of the total loss is due to the core loss, the core loss also can be expressed in radians, and if it is only one-tenth of the total resistance, its loss angle is only one milliradian. If it is to be measured to an accuracy of ten per cent, the angular error of the bridge can not be greater than 0.1 milliradian. This means that the loss angles of the standards used with the bridge must be known to at least this precision.

In considering possibilities for a bridge of improved accuracy, these factors were all kept in mind. A

bridge of the comparison type was rejected because with it the standards should be better than the specimen under test, while the purpose of this project was to develop materials better than any existing. The series resonance bridge was considered because it uses a condenser standard, which can be built with a much smaller loss angle than an inductance. This type of bridge is not direct reading, however, and the computation labor involved is a great handicap when numerous measurements are required. An investigation revealed, moreover, that a Maxwell bridge,* which has the advantage of being direct reading, could be built with equally good accuracy.

A simple schematic of the Maxwell bridge is shown in Figure 2. The condenser standard C_s balances the un-

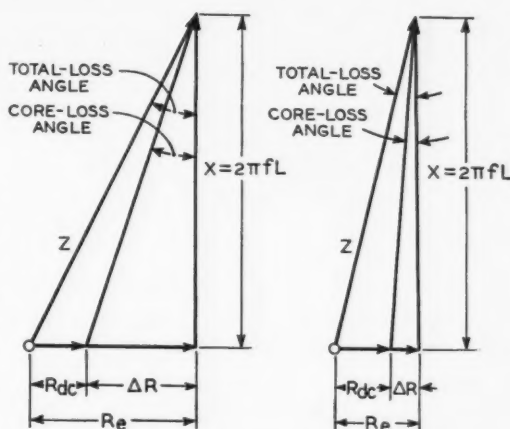


Fig. 1—With large core loss, indicated at left, ΔR can be measured with about the same precision as R_e , but with small core loss, its precision becomes less

known inductance L_x , and the conductance standard G_s balances the unknown resistance R_x . The factor $R_1 R_2$ is designated the product constant, and is usually made equal to some power of ten to facilitate com-

*RECORD, June, 1938, p. 343.

putation. In the new bridge the product constant is made 10^6 so as to permit using capacitance values giving the best accuracy for the usual frequency and inductance range. With a constant of this value, 0.1 micro-

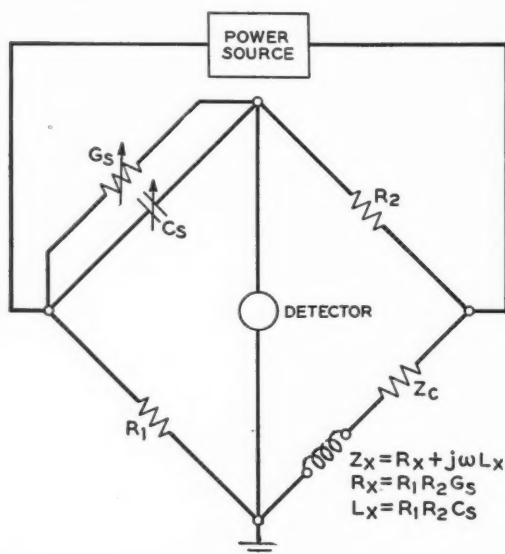


Fig. 2—Simplified schematic of Maxwell bridge for measuring core loss

farad in the bridge measures 0.1 henry of inductance. Since the capacitance and inductance values are numerically equal, the capacitance dials are engraved with the corresponding inductance values.

Formerly, resistance standards were used in Maxwell bridges for measuring resistance components. Since the resistance of the specimen is proportional to the conductance of the standard, however, it was necessary to take the reciprocal of the resistance standards inserted in the balancing arm. To eliminate this computation, a conductance standard was used for the new bridge as it has been in other recent Maxwell bridges. The conductance standard consists of three rotor-decade switches* and a

*RECORD, Jan., 1935, p. 136.

slide-wire dial, all connected in parallel instead of the series connection used in resistance standards. With such an arrangement the capacitance remains substantially constant, independent of the conductance setting, and the bridge can therefore be readily compensated.

If the conductance arm were designed to read zero conductance at its minimum setting, extremely large resistances would be required for many of the steps. Resistances in the megohm range, however, do not have the requisite stability and accuracy for a bridge of this type. For this reason a residual conductance of 100 micromhos was decided upon to keep all resistances to reasonable values. To offset this 100-micromho residual conductance, a 100-ohm resistor is inserted in series with the test terminals. In series with this resistance is a 200-microhenry inductance coil to compensate for 200 micro-microfarad residual capacitance of the standards and of the shields and wiring. Both this inductance and resistance are incorporated in z , as shown in the schematic diagram, Figure 2.

Considerable electrostatic shielding is required as indicated in the complete schematic of Figure 3. One of the requirements for a Maxwell bridge is that the phase angle of the two product resistors R_1 and R_2 be exactly equal but of opposite sign. R_2 , as any large resistance wound non-inductively, is capacitive, and R_1 is made inductive by adding a small series inductance L_1 . To secure simple and precise adjustment of the inductance of the R_1 - L_1 combination, it is shunted by a small adjustable condenser. To set this condenser at its correct value, precise tests of the bridge are made with all shields in place, and the condenser is adjusted with a screwdriver

inserted through a hole in the shield.

The two product resistors are purposely made unequal to secure more efficient use of the test current and to facilitate metering it. By making R_1 one hundred ohms, and R_2 ten thousand ohms, the current divides so that nearly all of it passes through the test specimen. Under these conditions, a reading of the current from the test oscillator may be taken as a measure of the test current where an accuracy of about five per cent is satisfactory. Where more precise measurement of the test current is necessary, correction factors are applied that depend upon the magnitude of the test impedance that is used.

One of the advantages of the Maxwell bridge for this type of work lies in the fact that when used with direct current, it operates as a Wheatstone bridge. Keys are therefore provided which make it possible to switch the bridge network to battery and galvanometer for measuring the d-c resistance of the test specimen without altering any of the lead and contact resistances, and without an elapse of time during which temperature changes might affect the resistance value. This feature adds appreciably to the accuracy in measuring resistance increments.

The bridge is made for relay-rack mounting as shown in the

photograph at the head of this article. The three rotor decades and the slide wire of the conductance standard comprise the upper row of dials, and below them are the four dials for the capacitance standard. The former are engraved in ohms and the latter in millihenrys so that the values of the test specimen are read directly. The range is from 0.001 to 100 ohms, and from 0.001 to 100 millihenrys. The bridge is designed for use with the operator either sitting or standing, and with the bridge mounted vertically this required that the dial indices be above rather than below the dials which is

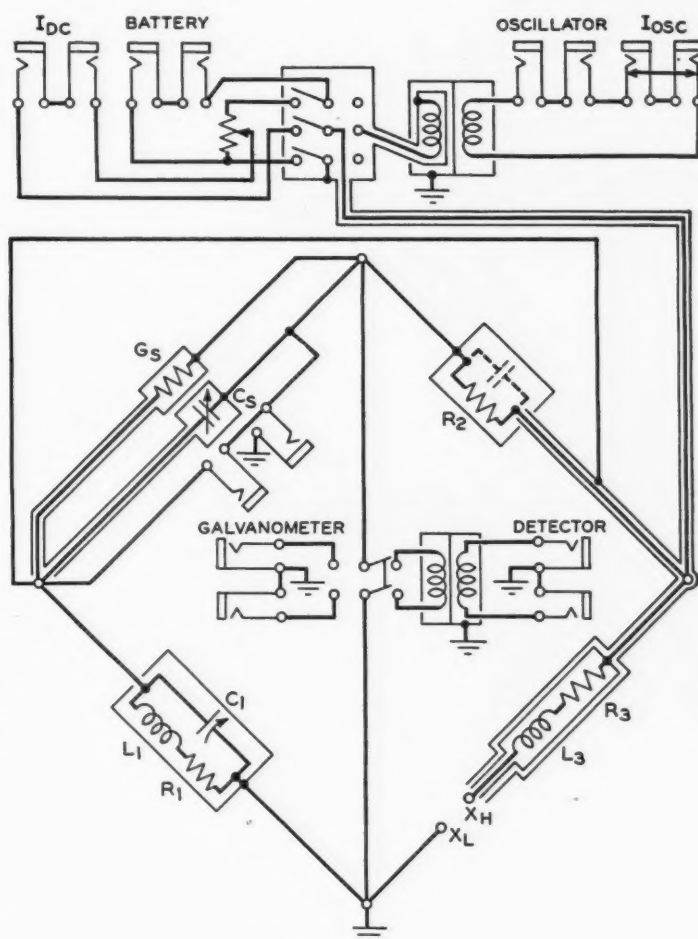


Fig. 3—Schematic of the new Maxwell bridge

common practice with horizontal bridges. This in turn made it necessary to change to a counter-clockwise rotation of the dial to maintain the left-to-right sequence of the dial markings. An adjustable apparatus shelf is provided at the left of the bridge to permit the test specimen to be near the bridge terminals and thus

to minimize corrections for long leads.

The bridge has demonstrated its value in furnishing precise core-loss data used in developing new magnetic materials. In addition, accurate frequency and current characteristics of completed filter and loading coils using these materials can be obtained with a minimum of effort.

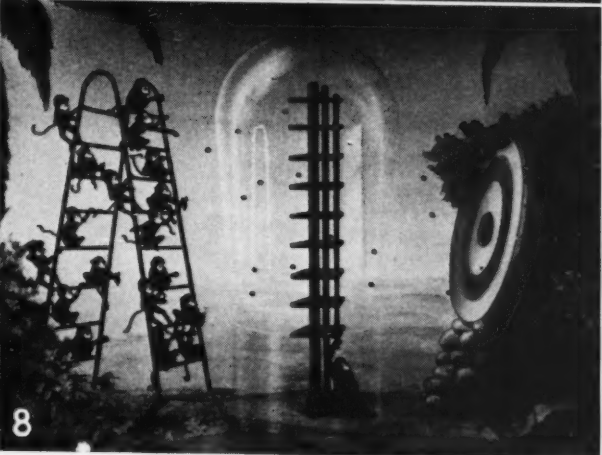
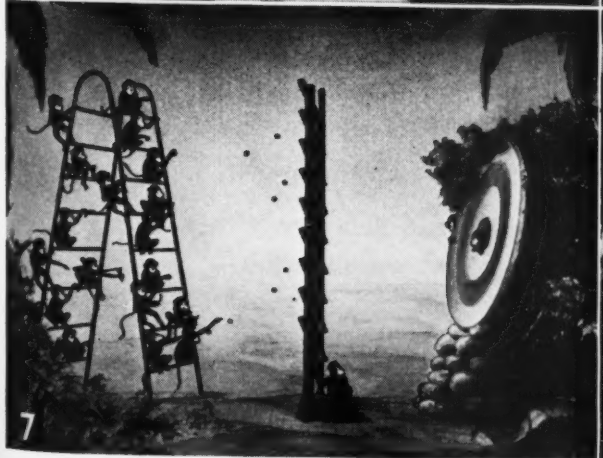
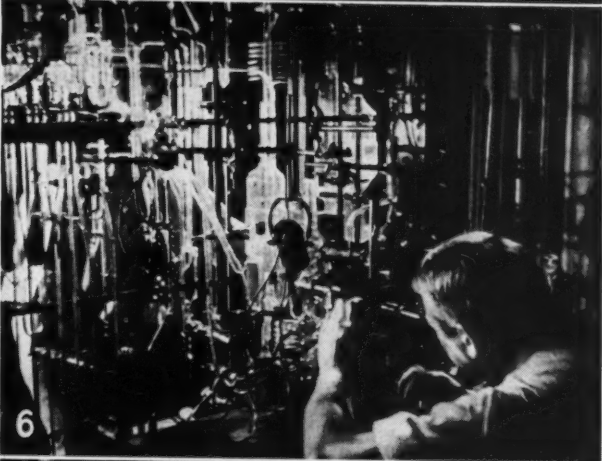
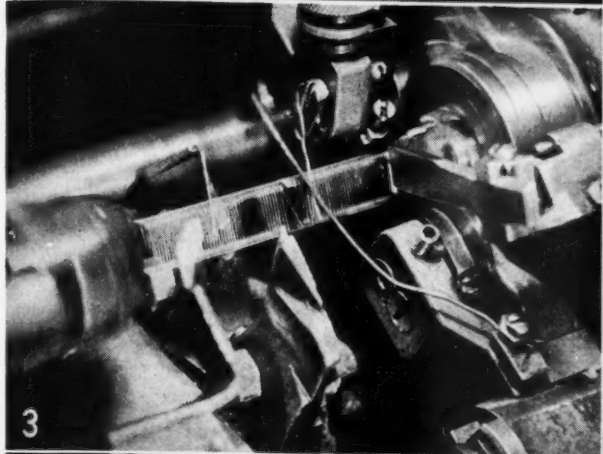
"A Modern Aladdin's Lamp"

A number of Laboratories engineers are members of the cast in the new Western Electric sound motion picture "A Modern Aladdin's Lamp," which describes the history, theory, manufacture and use of the vacuum tube. With Lowell Thomas as narrator, the film goes back to the discovery of the "Edison Effect" in 1883, through De Forest's invention of the control grid, through the development of the telephone repeater, and on to the current research in our vacuum-tube laboratory. Steps in manufacture are illustrated by scenes from the Western Electric factory, and some of the varied applications by shots of ship-to-shore stations, broadcast transmitters, sound-picture studios, telephone toll offices, and the like. Ingenious animations are used to explain the behavior of electrons in vacuum tubes and metal conductors.

Enlargements of a few frames from

the film are shown on the opposite page: 1—T. L. Tuffnell testing a repeater tube. 2—S. B. Ingram, E. G. Shower, J. E. Clark and V. L. Ronci in conference over a power tube. 3—An automatic grid-winding machine. 4—J. J. Heil sealing two glass tubes together in cross fires. 5—Examining tube parts under a microscope, in the Western Electric factory. 6—C. H. Prescott, Jr., with equipment used for analysis of gases. 7, 8—Two frames of the animated sequence showing a rough analogy of the control of a vacuum-tube grid on the electron flow; (7) symbolizes the grid biased to cut-off, and in (8) the grid potential permits a free flow of electrons.

Both 16 and 35-millimeter prints of the film are available for loan or purchase through the Western Electric Motion Picture Bureau, 195 Broadway, New York.





An Interpolation Method for Setting Laboratory Oscillators

By F. R. STANSEL
Apparatus Development

SINCE the introduction of vacuum-tube oscillators as common pieces of laboratory equipment more than two decades ago, their frequencies have been checked throughout the audio and carrier-frequency range by comparison against standard frequencies using Lissajous figures produced on a cathode-ray oscilloscope.* With these figures, frequency ratios of 1 to 1, 2 to 1, and in general n to 1 may be recognized and the oscillator may thus be set at integral multiples of the standard frequency. By providing standard frequencies of 100 cycles, 1000 cycles,

10,000 cycles, and 100,000 cycles these multiples cover a large portion of the calibration points required. Additional calibration points may be had by using other frequency ratios such as 3 to 2 or 4 to 5, but these patterns are not so easy to recognize as those of integral multiples and, except for the case of the $(n + \frac{1}{2})$ to 1 patterns, they are not generally of much practical importance.

Occasionally an oscillator must be set at an exact frequency which bears no simple relation to any standard frequency. The oscillator may then be calibrated at two or more points in the vicinity of this frequency, a curve

*RECORD, April, 1927, p. 281.

drawn between these calibrated points and the setting for the desired frequency read from the curve. This method has been widely used, especially in the lower carrier-frequency range where calibration points may readily be obtained every 100 to 500 cycles, but considerable time is required since a complete calibration may include over a hundred curves. Occasions also arise which demand greater accuracy than can be obtained by linear interpolation. More precise methods of frequency measurement are available,* but these methods have heretofore involved a large amount of apparatus and have been too complicated to be readily adapted to routine laboratory use.

Experiments showed that a simpler and less expensive method of measuring frequencies precisely would be to combine the unknown frequency of the oscillator under calibration with another frequency such that the difference between these frequencies is a multiple of a third known frequency. This can be done by applying these two frequencies to one pair of plates of a cathode-ray oscilloscope and observing the shape of the envelope of the complex wave form produced when a standard frequency is applied to the other plates. The W-10601 interpolation oscillator was developed on this principle. It provides a simple, fast and very accurate means of determining the setting of frequencies between the calibration points on a laboratory oscillator, or conversely of measuring the frequency interval between an unknown frequency and the nearest calibration point.

To explain the operation of this oscillator, let us first consider the shape of a complex wave composed of two frequencies. If these two frequen-

cies have equal amplitudes the wave appears like Figure 1a; if unequal like 1b.* In either case the frequency of the envelope is that of the difference between these two frequencies.

Let us now assume that we wish to set a laboratory oscillator at 323,383 cycles. The output of the interpolation oscillator is connected in series with the laboratory oscillator in the circuit shown in Figure 2. The interpolation oscillator is set at 11,383 cycles and a 1000-cycle standard frequency is applied to the oscilloscope. Next the laboratory oscillator is set

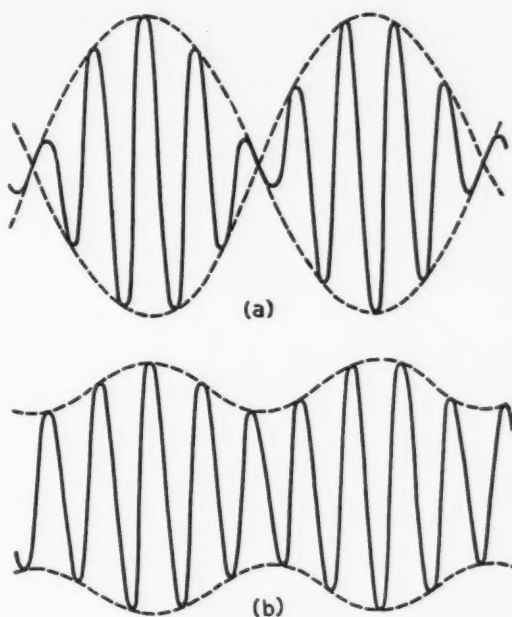


Fig. 1—Complex wave having two frequencies of equal amplitudes (a) and unequal amplitudes (b)

at 323,000 cycles from its previous calibration. This setting need not be accurate because it is made only to insure that the final setting is not in error by 1000 cycles or a multiple of

*The wave shape of Figure 1b should not be confused with that of an amplitude-modulated wave. Actually both waves appear very similar but there are fundamental differences.

*RECORD, Aug., 1931, p. 585.

1000 cycles. The frequency of the laboratory oscillator is then increased. The envelope of the composite wave now appearing on the oscilloscope is the difference between the frequencies of the laboratory and interpolation oscillators but no pattern is observed until the laboratory oscillator's frequency reaches 323,383 cycles when this difference frequency becomes 312,000 cycles. As this is a multiple of the 1000-cycle standard frequency a figure similar to Figure 1a or 1b is then seen in the oscilloscope, except that the individual oscillations are not distinguishable because of the high frequency. Actually two patterns appear, one moving from left to right and the "back trace" from right to left. They may be separated by one of the phase-splitting circuits used with Lissajous figures* although this is not

interpolation oscillator is varied until the pattern appears and the frequency increment read from its scale.

In the above illustration a frequency of 11,383 cycles was used but the patterns may be obtained with any frequency which gives a multiple of 1000 cycles when subtracted from or added to the desired frequency. For example, a pattern may be found with the frequency of 323,383 cycles by using an interpolation frequency of either 11,383 cycles (11,000 plus 383 cycles) or 10,617 cycles (11,000 minus 383 cycles). It is therefore necessary for the interpolation oscillator to cover a range equal to only half the value of the frequency standard. This allows the frequency scale of the interpolation oscillator to be spread out by a factor of 2 to 1, but introduces the complication of determining whether the increment frequency employed is to be added or subtracted.

When it is not apparent from the reading of the oscillator under calibration whether the increment is to be added or subtracted this ambiguity may be removed by increasing the frequency of this oscillator a few cycles. The interpolation oscillator is then varied until the pattern is again obtained.

If the interpolation frequency increases, the difference between the actual frequency of the interpolation oscillator and the nearest multiple of the standard is added to the reading of the oscillator under test.* If the interpolation frequency decreases, the increment is subtracted.

The interpolation frequency does not need to be as low as 11,383 cycles

*It is assumed that the laboratory oscillator has been previously calibrated in multiples of the standard frequency.

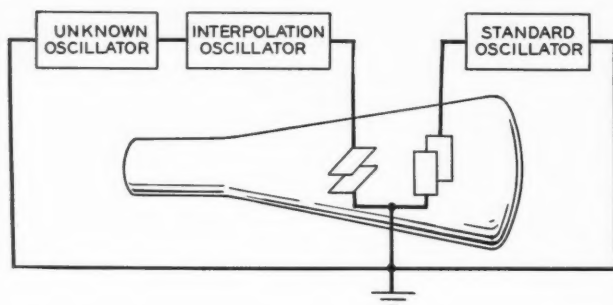


Fig. 2—Schematic circuit used in interpolating frequencies with a cathode-ray oscilloscope

generally necessary. When the laboratory oscillator is adjusted until this pattern is stationary, its frequency will be 323,383 cycles with an error in cycles numerically equal to the number of cycles that the interpolation oscillator is in error.

The circuit may also be used in a converse manner to find the frequency of an oscillator at an experimentally determined setting. In this case the

*RECORD, April, 1927, p. 281.

but may be of the same order of magnitude as that of the oscillator tested. A high interpolation frequency would have the advantage that the frequency of the envelope of the pattern is lower and hence the pattern is easier to spread out for observation on the oscilloscope. The absolute accuracy of this method, however, depends on the accuracy with which the interpolation oscillator may be set and hence the lower interpolation frequency is desirable. By using an interpolation frequency of the order of 11,000 cycles, it is not difficult to build, without bulky and expensive coils and condensers, an interpolation oscillator which has an accuracy of better than plus or minus one cycle. With such an oscillator it is possible to set a laboratory oscillator at any frequency up to well over a megacycle with an absolute accuracy of better than

plus or minus one cycle. For frequencies a few cycles either side of multiples of the standard, the Lissajous figures make observation of the envelope frequency difficult. In this region the frequency increment can be measured by timing the rate at which Lissajous figures proceed across the oscilloscope screen.

In the W-10601 interpolation oscillator, a 11,000 to 11,500-cycle oscillator is used in conjunction with the 1000-cycle standard frequency dis-

tributed throughout the Laboratories for frequencies up to about one megacycle. Above this range the patterns on the oscilloscope become crowded and it is difficult to obtain sufficient spread to make them recognizable.

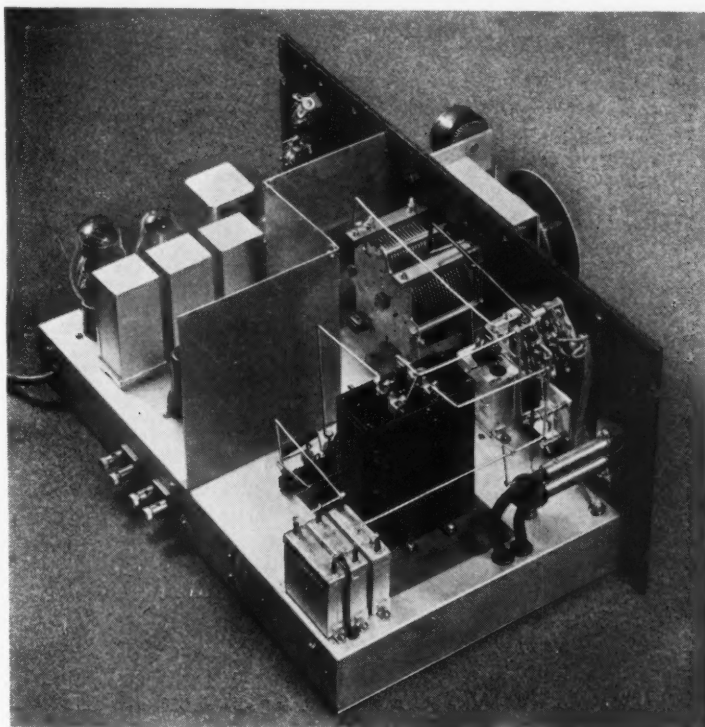


Fig. 3—The W-10601 interpolation oscillator determines accurately the frequency of settings between the calibration points of an oscillator or conversely measures the frequency interval between an unknown frequency and the nearest calibration point of the oscillator

Therefore a second range from 30 to 35 kilocycles is provided in the oscillator and this is used in conjunction with a 10-kc standard frequency. The absolute accuracy in this range is plus or minus ten cycles.

The scale of the interpolation oscillator does not indicate the actual frequency, but the frequency increment. The scale thus runs from 0 to .500 kilocycle on the low range and from 0 to 5.0 kilocycles on the high range. An additional set of scale markings reading

from .500 to 1.000 kilocycles on the low range and 5.0 to 10.0 kilocycles on the high range is used when the increment frequency must be subtracted.

To obtain a scale long enough to permit reading the frequency to better than one cycle, it is printed on 16-mm. film and connected by a worm-drive mechanism to a variable air condenser. The headpiece shows this scale with its cover removed to expose the drive mechanism and also an auxiliary coarse scale on a dial which is used to locate settings quickly. The worm drive covers each of the two frequency ranges by ten turns of a crank. The scale for both ranges is approximately 50 inches long, thus permitting the .5-kc scale to be graduated in one-cycle divisions and the 5-kc scale in 10-cycle divisions. Even longer film lengths can be accommodated by the mechanism. A light be-

hind the film illuminates the scale and it is read through a window in the housing. There are mechanical stops at each end of the film which operate without straining the condenser.

The W-10601 interpolation oscillator is mounted on a standard relay rack panel with the circuit components on a chassis fastened to the rear of the panel. The apparatus is designed for use with any three-inch cathode-ray oscilloscope of the types commonly found in the Laboratories. In addition to the oscillator for producing the interpolation frequency, it incorporates a mixing circuit, two amplifiers to give additional spread on the horizontal and vertical plates of the oscilloscope and a power supply for operation directly from an a-c line. This device has been found very useful in making accurate determinations of the setting of oscillators.



A new Western Electric "custom-built" speech-input equipment is assembled on a unit basis. The central member supports the control panel, and the flanking pedestals and turntables are added as required

Contributors to this Issue

H. T. WILHELM joined the electrical measurements group of the Laboratories in 1922. In 1924 he left to complete his studies at the Cooper Union Institute of Technology. Upon graduation in 1927 with a B.S. in E.E. degree, he resumed his work with his former group. He has been engaged in the preparation of testing specifications and the design and development of impedance standards, bridges and other test circuits. During this time he has taken graduate work in physics and electrical engineering. In 1936 he received the degree of Electrical Engineer from Cooper Union.

R. S. CARUTHERS received the B.S. degree from the University of Maryland in 1926, and then spent two years with the General Electric Company. During this period he studied for his master's degree under arrangement with the Massachusetts Institute of Technology and received the M.S. degree in 1928. Two years later he received an E.E. degree from the University of Maryland. He then spent a year with the Bureau of Standards and joined the Technical Staff of the Laboratories in 1929. Since then he

has been engaged exclusively in the development of carrier systems, chiefly the K, J, and coaxial systems.

W. E. DARROW received the A.B. degree from the University of Michigan in 1909 and the B.E.E. degree in 1911. He joined the Plant Department of the New York Telephone Company at Newark, New Jersey, in 1911, transferring nine months later to the Engineering Department in New York where he was engaged in the development of private branch exchanges. In 1919 Mr. Darrow joined the Engineering Department of the American Telephone and Telegraph Company and was placed in charge of a group responsible for the development of manual central office facilities. He continued this work in the Department of Development and Research when this was formed a few months later. When the Department of Development and Research was merged with the Laboratories in 1934, he became Manual Engineer of the Local Central Office Facilities Department.

F. R. STANSEL joined the Laboratories in 1926 after receiving the B.S. in E.E. degree from Union College that year.



H. T. Wilhelm



R. S. Caruthers



W. E. Darrow



F. R. Stansel



D. B. Herrmann



J. B. Dixon

Until 1936 he was engaged in the design of high-power radio transmitters for broadcasting and transatlantic service at the Whippany laboratory. Since then he has been associated with the development of oscillators and detectors for test purposes. In 1934 Mr. Stansel received the M.E.E. degree from Brooklyn Polytechnic Institute.

D. B. HERRMANN first came to the Laboratories in 1923 to work in the messenger service and Patent Department, and later in the Chemical Laboratories as a laboratory assistant. He left in 1925 to attend the College of the City of New York, but returned the two succeeding summers. In 1928 he rejoined the Laboratories' staff. Since then his work has been concerned primarily with problems relating to organic substances used as insulation on wire and cable, particularly rubber and similar materials, and with measurements of their dielectric properties. He has also studied the diffusion of water through organic insulating materials and, recently, the effect of various pigments on the dielectric properties of

rubber. In 1930 he received the Bachelor of Science degree from the College of the City of New York.

J. B. DIXON entered the student engineering course of the Westinghouse Electric and Manufacturing Company at Pittsburgh after graduating from Pratt Institute in 1918. He spent several years in the Engineering Department of this company on railway electrification problems and then transferred to the Public Service Electric Company of New Jersey, where he worked in their Plant Department on power and light distribution lines. In 1923, he was employed by the New York Telephone Company in the Outside Plant Engineering Department to work on cable-testing and cable-joining problems. Mr. Dixon transferred to the Development and Research Department of the A. T. & T. in 1926 for similar work. When the Outside Plant Department was formed in the Laboratories in 1927, he left the D & R to engage here in development problems pertaining to wire and wire products for outside plant use. He still continues in this line of work.